A Review Paper on Evaporative Cooling Methods

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ABSTRACT

Evaporative cooling is an energy efficient and environmental friendly air conditioning technology. Evaporative cooling has a great many advantages over other cooling processes. Due to the non-pollution creating environment. It is considered as one of the suitable ways to cool ones workplace or living place, because of the fact that it uses fresh air and replaces the air time to time to maintain room temperature. Due to recirculation of air, smells and allergens are expelled out. It is based on a natural process of air cooling by water, it won't dry out the air, or irritate human skin, eyes, or other external parts of the human body. Moreover, evaporative cooling is an inexpensive cooling option which enhances the lifestyle of people. However, evaporative cooling requires an abundant water and is efficient when the relative humidity is low. Experimental and theoretical research work on feasibility studies, performance test and optimization as well as heat load calculations are considered and then reviewed in detail. Always an attempt is made to obtain the saturation efficiency at optimum water consumption rate. The feasibilities of evaporative cooling under different climates, efficiencies of various evaporative cooling equipments and critical parameters and techniques for improving the efficiencies as well as numerical modeling of evaporative cooling processes.

Keywords*: Evaporative cooling, Saturation efficiency.*

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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 [1-4]. 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. It brings the comfort by increasing the humidity in dry climates, improves the air quality, and makes the air more breathable. The most familiar example of this is cooling effect of evaporating perspiration on the human skin. In dry hot climates body temperature is partially controlled by the rapid evaporation of perspiration from the surface of the skin. [2-5] The evaporation rate is raised as air movement is increased. Both of these facts can be applied to natural cooling of structures. This evaporation results in a reduced temperature and an increased vapor content in the air. The bigger the area of contact between the air and water the more evaporation occurs, resulting in more cooling and the addition of moisture. [6-8].

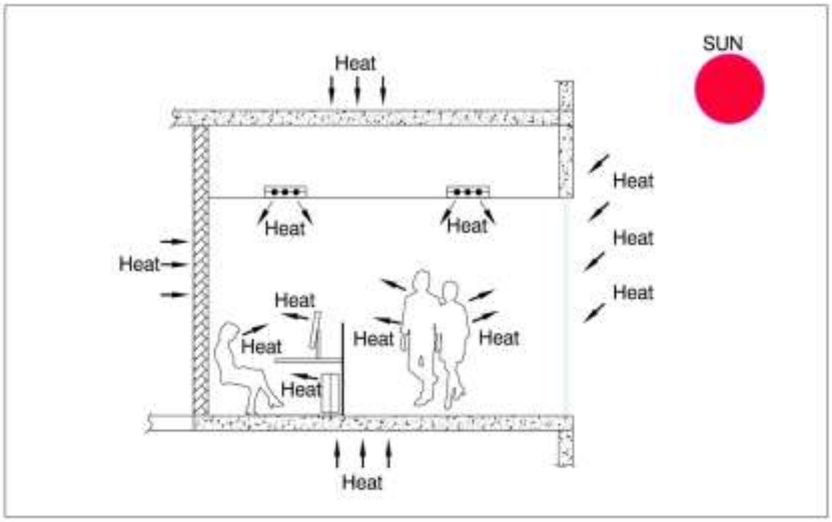

Fig. 1.1. Variours considerations during heat load calculation.

In the fundamental basis for understanding any air conditioning, dehumidification and evaporative cooling is ***psychometrics***. It consist of the interaction between heat, moisture and air. It is basically the study of air water mixture and is an essential foundation for understanding how to change air from one condition to another to rises its capacity to hold moisture. This makes moisture a very influential factor for heat gain, both for comfort and in calculation. The knowledge of the system consisting of a dry air and water vapour is essential for the design and analysis of air conditioning devices, cooling towers and industrial processes which requiring close control of the vapour content in air. Air moisture and heat interaction fortunately, these interaction can be combined in a single chart. This rate of evaporation of water purely depends on the temperature humidity of the air as well as the pressure of the particular place. Hence, sweat accumulates more on hot humid days in which the perspiration is impossible to evaporate. Energy demand worldwide for building 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 stands 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 [8-10].

2. PRINCIPLES OF EVAPORATIVE COOLING

When trying to understand evaporative cooling, it may be the best to think of air as being like a sponge or cooling pads , in that regard, air has an ability to absorb moisture that it come in contact with. The amount of moisture that the air will absorb depends on the state of air and the temperature of the air. If the air is warm and contains only a small amount of moisture, it will more radially absorb moisture. As air cools, it volumes decreases, and with it, its ability to absorb moisture decreases. Cooling through evaporation is a natural occurrence and the most common we all experiences is perspiration, or sweat as perspiration evaporates, it absorbs the heat to cool our body. It is a heat and mass transfer process that requires water for evaporation for the coolness in which heat is transferred from air to water and simultaneously the temperature of air decreases [7-9].

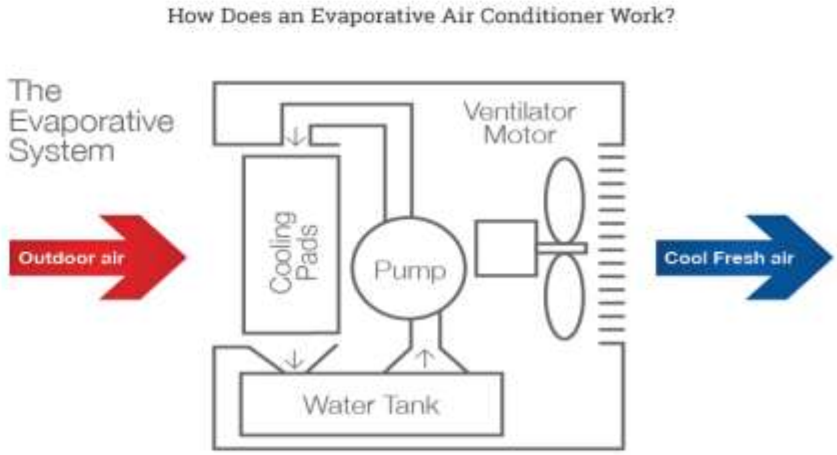

Figure: 2.1.Basic evaporative principal

The principle underlying evaporative cooling is the facts that water must have heat applied to it to change from liquid to vapour. When evaporation occurs, this heat is taken from the water that remains in the liquid state, resulting in a cooler liquid.

The evaporative coolers are classified as:-

1] Direct Evaporative [Working fluid as water and air in direct contact]

2] Indirect Evaporative cooler [Surface plates separates the working fluid].

3] Combination of both the Direct and Evaporative Coolers [With different cooling cycles] [1]

2.1. Direct Evaporative cooling (open circuit)

Direct Evaporative cooling introduce water directly into the supply air stream (usually with a spray or some sort of wetted media). As the water absorbs heat from the air, it evaporates and cools the air. In direct evaporative cooling the dry bulb temperature is lowered but the wet bulb temperature remains unchanged. In operation a blower pulls the air through permeable water –soaked pad. As the air passes through the pad, it is filtered, cooled and humidified [6]. A recirculation pump keeps the media (pads of woven fiber or corrugated paper) wet, while air flows through the pads. To ensure that the entire media get wet, more water is wet, more water is usually pumped and can be evaporated and excess water drains from the bottom into a sump. An automatic refill system replace the evaporated water the efficiency of direct cooling depends on the pad media. A good quality rigid cellules pad can provide up to 90% saturation efficiency while the loose aspen wood fiber pads shall result in 50 to 60 % contact efficiencies.

Figure: 2.1.1. Evaporation of water at pad to produce coiling effect.

2.2. Active Direct Evaporative cooling Systems

The active direct evaporative coolers are electricity-driven systems, however, it use a fraction of power for air and water circulation. So, it is considered much less energy intensive than other traditional cooling technologies, with energy saving up to 30% [3]. A typical direct evaporative cooler comprises of evaporative media (wet able and porous Pads), fan blows air through the wetted medium, water tank, recirculation pump and water distribution system, as illustrated schematically in Fig. 2.1.1. The direct evaporative cooling is an adiabatic cooling process, i.e. the total enthalpy of the air is constant throughout the process, as shown in Figure. The water absorbs the sensible heat from the supply air and evaporates causing the air temperature decreases and its humidity to increase [4]. Theoretically, the supply air could be cooled to 100% effectiveness, but in such process a wet-bulb effectiveness of 70 % - 80 % only is achievable because of short contact time between the two fluids, insufficient wet ability of the pads. Eventually the system would not be able to cool down the incoming air lower than its wet-bulb temperature. The wet-bulb effectiveness could reach range between 70-95% in most current commercial processes [7].

2.3. Passive Direct Evaporative cooling Systems

Passive cooling techniques use natural phenomena, energies, and heat sinks for cooling buildings without the use of mechanical apparatus consume electrical energy. However, small fans and pumps could be required. Passive DEC is depends on the climate which means the techniques applied for hot and humid regions are different from those for hot and dry areas. This technology is able to reduce indoor air temperature by about 9 ℃.

3.1. Indirect Evaporative Cooling

Indirect evaporative cooling lowers the temperature of air via some type of heat exchanger arrangement, in which a secondary airstream is cooled by water and which in turn cools the primary airstream. The cooled air never comes in direct contact with water or environment. In Indirect evaporative cooling system both the dry bulb and wet bulb temperature are reduced Indirect evaporative cooler do not add humidity to the air, but cost more than direct coolers and operate at a lower efficiency the efficiency of indirect cooling is in the range of 60 – 70 %.

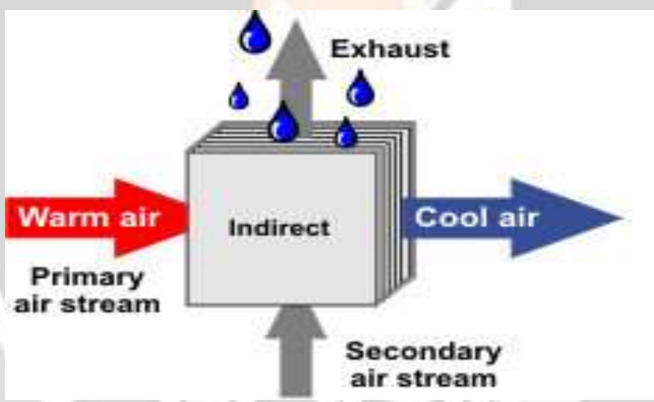

Figure: 3.1.1. Indirect evaporative cooler system.

4.1. TWO STAGE INDIRECT/DIRECT EVAPORATIVE COOLING

Two stage evaporative coolers combine indirect with direct evaporative cooling. This is accomplished by passing air inside a heat exchanger that is cooled by evaporation on the outside. In the second stage, the pre cooled air passes through a water-soaked pad and picks up humidity as it cools. Because the air supply to the second stage evaporator is pre cooled, humidity is added to the air whose affinity of moisture is directly related to temperature. The two stage evaporative cooling provides air that is cooler than either a direct or single stage system which can provide individually. In many cases, these two stages-systems provide better comfort than a compressor-based system, because they maintain a more favorable indoor humidity range.

An advanced two stage evaporative cooler uses 100% outdoor air band and a variable speed blower to circulate air. Two stage evaporative coolers can reduce energy consumption by 65-70% over conventional air conditioning systems, according to the American Society of Heating and air conditioning engineers.
Yet this relative improvement depends on location and application.

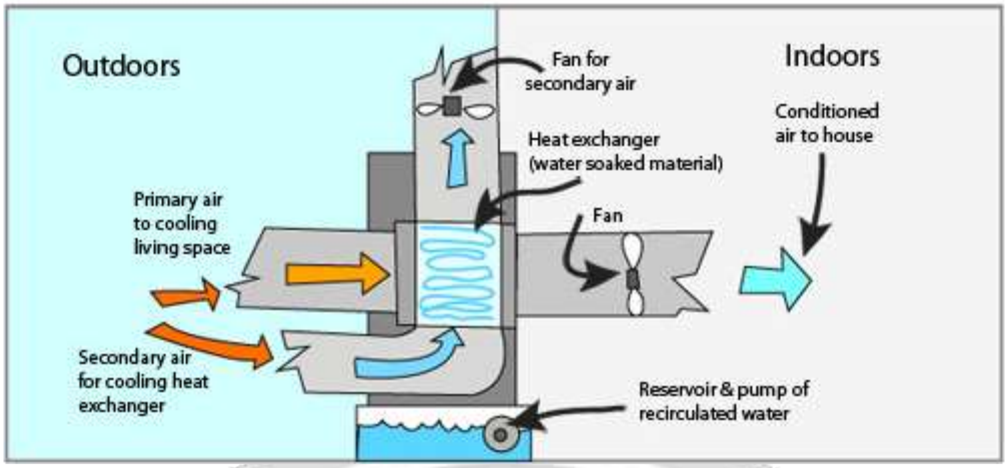

Figure: 4.1.1. Two stage indirect/direct evaporative cooling

5. CONCLUSIONS

As using the water for the evaporation purpose, which leads to decrease the temperature of the air also containing the most economically environmental effective system. In this review paper of evaporating cooling technology, methods are studied for the commercial and comfort purposes. Indirect evaporative coolers has shown higher values of effectiveness and more economically operated in the terms of energy consumption saving, particularly the M-Cycle, which is based on dew point IEC system. However the combined system of direct and indirect cooling system have similar performance or even the higher but their system consist of higher initial cost and the major problems like noise & vibrations, pressure loss and friction loss. Recent work on experimentations and the Methodologies suggested by the author have shown the considerable potential towards enhancing the performance and cooling capacity of the system for building cooling.

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BIOGRAPHIES

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