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Evaporative Cooling Methods : A Review

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ABSTRACT

Now days due to energy crisis and harmful effect to environment, there is more and more urgent need of energy saving in air conditioning and water cooling demands in mainly consideration of all the free cooling techniques. Among them evaporative cooling is well known technique from long time which gives good results and wide number of applications in residential, commercial, agricultural, and institutional buildings to industrial applications like as spot cooling in power plants, foundries, etc. This papers aims to review the recent development concerning evaporative cooling technologies that could potentially provide sufficient cooling effort, reduce environmental impact and lower energy consumption. The authors have reviewed various journal papers and suggested different schemes of classification. The review covers working principle, performance of evaporative cooling technology and also studied direct, indirect and direct-indirect cooling system. The study focusing on investigating the method of cooling, benefits in terms of power consumption, cost saving and various environmental aspects, In addition, certain gap areas are identified that would help researchers in future research.

Keywords: Evaporative Cooling, Energy Consumption, Method of Cooling, Environmental Aspects.

I. INTRODUCTION

Evaporative cooling has been in use for many decades in India for cooling water and for providing thermal comfort in hot and dry regions. Evaporative air conditioning systems offer an attractive alternative to the conventional summer air conditioning systems in places, which are hot and dry. Evaporative air conditioning systems also find applications in hot industrial environments where the use of conventional air conditioning systems becomes prohibitively expensive. In addition, evaporative cooling systems are more environmentally friendly as they consume less energy and their performance improves as air temperature increases and humidity decreases. As it is relatively cheap and requires less energy than other forms of cooling thus it has a prime importance in summer season and hot condition.

II. METHODS AND MATERIAL

A. DIRECT EVAPORATIVE COOLING (OPEN CIRCUIT)

Direct Evaporative cooling introduce waterdirectly 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.

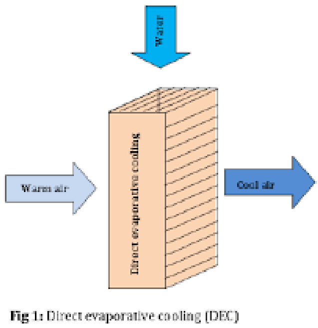

Figure 1. Direct Evaporative Cooler

B. INDIRECT EVAPORATIVE COOLING (CLOSED CIRCUIT)

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 temperatures are reduced. Indirect evaporative coolers do not add humidity to the air, but cost more than direct coolers and operate at a lower efficiency.

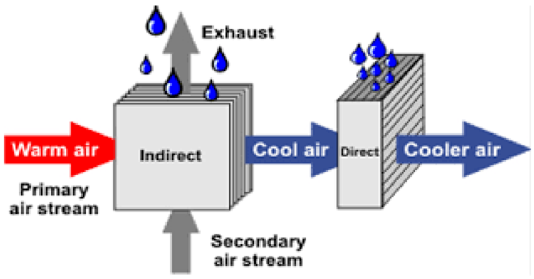

Figure 2. Indirect Evaporative Cooling

C. COMBINED EVAPORATIVE COOLING

This type of 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, less humidity is added to the air, whose affinity for moisture is directly related to temperature. The two-stage evaporative cooling provides air that is cooler than either a direct or indirect single-stage system can provide individually. In many cases, these two-stage systems provide better comfort than a compressor-based system, because they maintain a more favorable indoor humidity range.

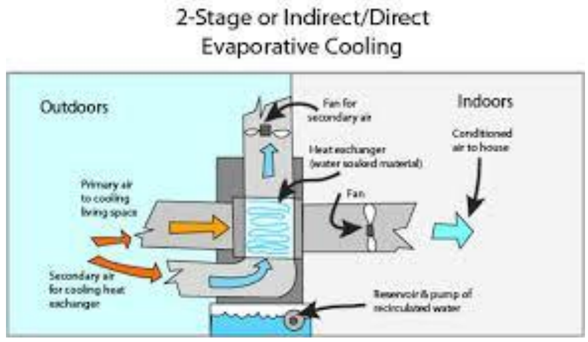

Figure 3. Combined Evaporative Cooling

D. ACTIVE DIRECT EVAPORATIVE COOLING

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% . 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 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 . 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.

E. PASSIVE DIRECT EVAPORATIVE COOLING

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 °C.

III. RESULTS AND DISCUSSION

Various cooling technology been studied here but a lot more can be developed to increase cooling efficiency. Combined evaporative method is most efficient but also being on high cost its losses its economy. Direct method is mostly used in many country as it the cheapest method with less maintenance.All these methods order can be developed to provide cooling at zero energy cost, no harmful effect to environment and also having low initial cost.

IV. CONCLUSION

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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