

# A Review Paper on Effectiveness of Evaporative Cooling System

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**Abstract:** This work aims to modify the design of conventional direct evaporative cooler to make it capable of providing an effective cooling effect with minimum energy consumption. The conventional evaporative cooler has the capacity to provide cooling effect with modification in its design and cooling pad materials. Efficiency and effectiveness of evaporative cooling depend on the rate of evaporation in the cooling medium. In modified design cellulose pad are used in which water and air contact with cross flow arrangement it increases the rate of heat and mass transfer between water and air thus provide the maximum cooling effect. Cellulose cooling pad corrugated paper which is locally available cheap material. This pad is compact in size which reduces the overall size of cooler making it light in weight and suitable for wall mounting.

**Keywords:** Cellulose pad corrugated paper, Cross flow, Evaporative cooling, etc.

## I- INTRODUCTION

Commercially for human comfort vapour compression refrigeration system is used in an air conditioning system. Which has a high running cost due to the compressor. The cost of this type of air conditioning system is also high as compare to the evaporative cooling system.

Due to the increase in energy demand there is more and more urgent need to save energy. As we all know the evaporative cooling is one of the best options amongst them, these ancient techniques used for cooling purpose. This technique has a wide number of applications in residential, commercial, agricultural and food storage

etc. so in this paper, he studied various evaporative cooling methods to find out the best suitable and environmentally friendly way of cooling. This paper reviews various studies carried out related to the evaporative cooling system recently and in the past.

### Evaporative Cooling Working Principal

Evaporative cooling is one of the types of thermodynamic process. It works on the simple principle of the evaporation i.e. cooling effect is occurred when water is evaporated from the surface. Thus evaporative cooling is a natural process in which dry atmospheric air passed from one side of the wet porous cooling pad and due to evaporation process cool air is obtained from another side. The pad with good heat transfer characteristics and good water absorbing capacity can give maximum efficiency.

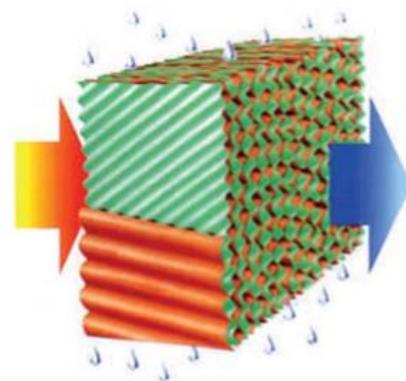


Fig. No. 1- Diagram of Evaporating Process

### Type of Evaporative Cooling

Evaporative cooling is divided into two main types  
a) Indirect Evaporative Cooling

## b) Direct Evaporative Cooling

In indirect evaporative cooling air is pre-cooled before it passing through humidifier or vice versa.

In direct evaporative cooling air is directly passed through a humidifier.

The direct evaporative cooling system further divided into two types

a) Active type direct evaporative cooling system

b) Passive type direct evaporative cooling system

In active evaporative cooling system, the fan or blower is used to pass air from humidifier and passive type direct evaporative cooling system the naturally available air velocity used for cooling purpose.

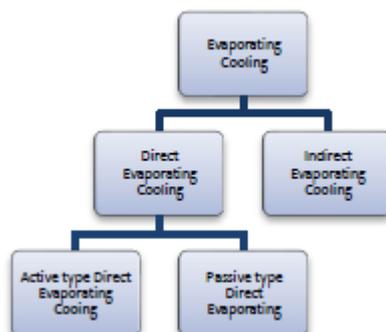


Fig. No. 2- Evaporative Cooling

### Cooling Pad Material Available for Evaporative Cooling

In evaporative cooling water is a main working fluid and material used for cooling pad should have high water absorbing capacity. It should have a high porosity. It should have good heat transfer capacity. These are the main influencing factors. Wood wool, Coconut hair, Kush pad, Palash tree roots, Cellulose pad, Porous ceramic pad, PVC pad, Charcoal latex foam, Hessian pad etc are some organic and inorganic materials that have been tested for cooling pad material.

## II- REVIEW OF LITERATURE

**Mr. R. K. Kulkarni** has suggested that Evaporative cooling technology is environmentally friendly. This has the potential to minimize the use of CFCs/HFCs. The performance of experimental indirect & direct two-stage evaporative cooler is evaluated with different materials and shapes of cooling media in a direct stage. Average inlet dry bulb temperature was varying between 39 °C and 43 °C and relative humidity between 37 % and 46

%. Saturation efficiency of direct cooling mode ranges between 98.3 % and 71.9 % and cooling capacity ranges between 3240 kJ/h and 45427 kJ/h for different material and pad shapes. The combined mode gives the overall efficiency of 119.5 % to 74.3 % and cooling capacity of 4679 kJ/h to 43771kJ/h for different pad shape and material combinations. The outlet temperature of air ranges between 27.3 °C and 32.4 °C in two-stage operation. The results show that the cooling efficiency can be improved by adding an indirect stage before the direct stage and the dry bulb temperature of incoming air can be reduced below its wet bulb temperature. Efficiency values are higher for the material with high wetted surface area, low mass flow rates of air and low velocity. Rectangular shapes are having high efficiency with low mass flow rates of air and low velocity. At maximum mass flow rates, the velocity of air remains approximately the same with different shaped pads but slightly higher mass flow rates are obtained with semi-cylindrical and semi-hexagonal pads. Hence these shapes are suitable for higher mass flow rates of air. The efficiency with semi-cylindrical and semi-hexagonal shape is better at a lower range of mass flow rates also. Water consumption of the cooler varies between 3 and 6 lit/hr depending on the mode of operation and the material used. The maximum power consumption in direct mode is around 203 W while that in combined mode is 418 W. This type of two stages cooler will be suitable for the tested range of climatic conditions of 39 - 46 °C DBT and 37 - 46 % RH. Exchanger dimensions, flow rate, which affects the performance of heat exchanger.

**V.S. Shamma** has concluded that an important point is to understand that the temperature of the water does not have any real effect on the cooling produced by the evaporation process.

**Abdulrahman et al** analyzed the experimental performance of direct evaporative cooler operating in Kuala Lumpur. The cooler consist of a cellulose pad with surface area 100m<sup>2</sup> per unit volume. The performance of evaporative cooler evaluated in terms of output temperature, saturation efficiency and cooling capacity. The output temperature lies in the range of 27.5°C and 29.4°C, and the cooling capacity is between 1.384 KW and 5.358KW.

**Mr. Thunga et al** proposed model is to design an ECO AIR HUMIDIFIER which uses evaporative cooling to provide an air flow that is cooler than the surrounding air. The blower and pad system consists of a large centrifugal blower, in warm climates and houses tall

gutters (>12ft), 11-14 CFM per square feet is advisable. This basic air flow rate is then adjusted for elevation over 1000 feet above sea level, the expected interior light intensity the allowable greenhouse temperature increase, distance from the pad to the blower. The pad to the blower distance ranges From 100-200 ft.

Cross fitted cellulose pad, 4 inches thick can move 250 CFM per ft sq. Water must be delivered to the top of a 4inch thick pad at the rate of 0.59 meter per linear ft of pad per pad length of 30-50ft, 1.5 inch water distribution pipe is required, while for length 50-60ft, a 1.5 inch pipe is needed. The sump tank volume should be at least 0.75 gal/ft sq of 4 inch pad 1.0 gal/ft sq of 6 inch thick pad. The impeller is typically gear driven and rotates as fast as 15000rpm. The cooling controller is designed for the management of refrigeration food processing applications. The controller has INTC input for ambient deforest temperature and 2 relay output for control purposes. Relay action-cool 85-270 volt AC/DC supply voltage.

This paper concludes that it has provided an initial analysis into a new era of designing and a new working model of the humidifier with evaporative cooling pads. The present devices can provide years of trouble-free service and cool, clean, comfortable fresh air at a lower energy cost than conventional air conditioners. At the future extension the level in addition to improving the performance.

**Dipak Ashok Warke et al** in this paper the performance of two types of cellulose pad are getting tested. The pad no 5090 and 7090 which are made from corrugated paper. The whole experiment is performing in a subsonic wind tunnel. The pad area is to be considering  $0.35 \times 0.35$  m<sup>2</sup> sheet with a thickness of 50,100 and 150mm.

In the experimental set up it observed that at moderated speed the efficiency of cooler getting high if we increase the speed over moderated speed the heat transfer coefficient also increases. In other case khus pad having 20mm thickness shows the maximum efficiency of 48.62% and 40mm thickness of khus pad shows 33.72% maximum efficiency. Cellulose pad has more potential to provide cooling as compared to khus pad and aspan pad. In which aspan pad with thickness 36mm gives maximum saturation efficiency of 78.38% also the maximum saturation energy of 90.37% and overall we can conclude that cellulose pad is more efficient overall Kush pad. The efficiency may vary when the thickness of pad increased or decrease it directly affect the cooling factor.

**S.S Kachava el al** in this paper a simple and efficient methodology is presented to design a household desert cooler, predict the performance of evaporative medium and determine pad thickness and height for achieving maximum cooling. For formulation inlet air DBT and humidity ration, air velocity, water temperature flow rate, and geometrical properties of an evaporative medium. A test rig was fabricated to collect experimental data. Satisfactory predictions of air condition at a cooler output for given input were obtained. Exit air temperature variations are found to be around 15% and humidity ratio 10%. These results are useful for size selection of medium geometry required for an evaporative cooler design.

While performing this experiment, it indicates that DBT decrease by 10°C and this experiment was conducted during the dry months. As per the experiment, the temperature and relative humidity vary by  $\pm 15$  and  $\pm 10$  respectively.

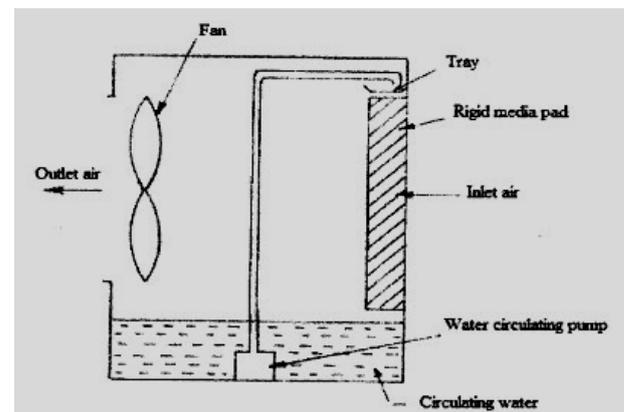


Fig. No.3- Household Dessert Cooler

**Rajesh Maurya et al** conducted a test on three types of cooling pads in which velocity is varied from 0.5 m/s to 3 m/s in wood wool (Aspen pad). 2.61 kg/hr to 10.88 kg/hr water is consumed with saturation efficiency 80.99% to 68.86% with cooling capacity 6328 kg/hr to 34153 kg/hr with RH 79.79% to 68.86%. When velocity is varied from 0.5 m/s to 3 m/s in coconut coir 2.13 kg/hr to 9.15 kg/hr water consumed with saturation efficiency 68.15% to 50.79% with cooling capacity 5660 kg/hr to 25262 kg/hr RH 68.048% to 55.68%. When velocity is varied from 0.5 m/s to 3 m/s in cellulose pad 2.18 kg/hr to 10.46 kg/hr water is consumed with saturation efficiency 69.58% to 56.4% with cooling effect 5766 kg/hr to 28084 kg/hr with relative humidity of 69.73% to 59.56%. From above data, it is seen that the efficiency of the cooling pad is directly proportional to pad thickness

if the thickness increases the efficiency of the pad also increases also saturation efficiency is inversely proportional to air flow as air flow rate increases saturation efficiency decreases.

**Sachdeva et al** analyzed the performance of direct evaporative cooler on the basis of heat and mass transfer. Pads having different thickness are used for finding the effect of variation in some parameters like wet bulb saturation effectiveness, COP, Nu, HTC, CC and water consumption with varying face velocities. Results of this analysis showed that with an increase in pad thickness, wet bulb saturation effectiveness increases and with an increase in face velocity wet bulb saturation effectiveness decreases. High wet bulb depression results in high-temperature drops. Also, the higher cooling capacity of the system is observed at high WBT.

**Shashank Shekhar et al** he suggested that The ease of installation, consumption of power and maintenance estimates the evaporative cooling at a price nearly one-fourth of the air conditioners system. The constant and high volumetric flow rate of air reduces the temperature of the air. It improves the condition of the climate inside the room. Electricity consumption is reduced and water saving is also a concern. From the comparative account, it has been observed that the vertically aligned galvanized metal sheets could withstand any environment in the country's scenario and the cooling efficiency is nearly 83% above all the performance indicators of the various evaporative coolers. In the new designed pads arrangement, it is easier to remove salt deposition and dust build up over the pads surfaces. Certainly, this will give a longer useful life compared to the commercially available cellulosic pads.

**Dr.J.P.Yadav et al** the very commonly used desert cooler in any household is unable to provide sufficient cooling especially in April, May and June. Tests performed on common dessert cooler performed in Delhi and Rajasthan where the temperature is high and humidity is very low which is not sufficient during summer. Heat given off from human body as either sensible or latent heat. In order to design design any air-conditioning system for spaces which human bodies are to occupy, it is necessary to know at which these two forms of heat are given off under difference. Here the dessert cooler is modified to control humidity of the room by providing heat to the heating coil which is placed near the cooling pad. This will obtain by decreasing the humidity level and increasing the temperature level of room. In which the cooler will

decrease the temperature up to 18-20°C and the humidity by 20%.

### III- CONCLUSION

This paper under look at a review based study into the evaporative cooling technology in terms of its background, originality current status and researches.

This data is significant for developing new design related to evaporative cooling. By getting more cooling effect with the minimum used of energy and water at reasonable cost.

It is observed that the evaporative air cooler takes more floor space and by using wood wool for cooling purpose the consumption of water is more. On the other side, due to continuous running of cooler, the moisture generates inside the room is more and feels uncomfortable during summer. So to overcome these problems, we are designing the wall mounted air cooler using cellulose pads which will be mounted on wall with good air ventilation, so the moisture inside the room will be maintained and can used the floor space for other purposes. Also we can reduce the consumption of water by using the cellulose pads for cooling of water.

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