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Design and Analysis of Evaporative Cooler to Increase its Cooling Rate by Changing its Material

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A B S T R A C T

Evaporative cooling is an air cooling system that is both energy-efficient and environmentally friendly. There are several advantages of evaporative cooling over other cooling methods. Because of the atmosphere created by non-pollution. As it uses fresh air and replaces the air from time to time to retain room temperature, It is known as one of the appropriate ways to cool one's workplace or living spot. Odours and allergens are expelled as a result of air recirculation. It is based on a natural water-cooling air mechanism that will not dry out the air or irritate human skin, eyes, or other outer parts of the human body. In addition, evaporative cooling is an affordable alternative for cooling that improves people's lifestyles. However when the relative humidity is low, evaporative cooling requires abundant water and is effective. Experimental and theoretical research work on feasibility studies, efficiency evaluations, and estimates of optimization and heat load was taken into account and then analysed in detail. An effort is often made to achieve saturation efficiency by altering the optimum cooling content (cooling pad). This research aims to investigate, by modifying the cooling pad materials, the efficiency of the direct evaporative cooler. The performance of the direct evaporative cooler depends primarily on the cooling pad and thus plays a very important role in the material used in the cooling pad. Here using cooling pads of four distinct materials such as cellulose paper pad, wood fibres, coconut fibres, and an earthen lamp with POP, the output of the cooler is evaluated. The performance of the direct cooling system is also analysed by using four different types of cooling pads simultaneously on three sides of the cooling pads, consisting of cellulose paper, coconut fibre and wood wool (Aspen) and earthen clay, in addition to these four types of cooling pads. Temperature and humidity are the two most important words regarded in this study. For each type of cooling pad, the readings of these two words are taken and further calculations are also performed on the basis of these readings. The outcomes of the various cooling pads were also compared. The paper rounds off the findings and the future research agenda for this field.

Keywords: Evaporative cooling, Humidity, Temperature, Pad, Cooler & Analysis.

1. Introduction

Through evaporating the liquid into the ambient air, evaporative cooling provides better cooling and cools the object and the room around it. As air, which has low humidity, moves over a wet surface, evaporative cooling occurs, and the cooling depends on the evaporation rate. By increasing the humidity in dry climates, it provides warmth, increases the consistency of the air and makes the air more breathable. The best instance of evaporative

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cooling by which we can balance the body temperature is perspiration on the human skin. Body temperature is partly regulated by the rapid evaporation of sudor from the surface of the skin in dry, hot climates. We may increase the evaporation rate by increasing the movement of the air. Both of these facts can be attributed to structures' natural cooling. The effect of this evaporation is a decreased temperature and an increased content of vapor in the air. If the region of liquid and air interaction is larger, the evaporation rate also increases and hence provides better cooling.

Psychometrics are the basic basis for understanding both air conditioning, dehumidification and evaporative cooling. It consists of heat, moisture, and air interaction. It is the analysis of the air-water mixture and is an important basis for understanding how air can be modified from one state to another to improve its moisture retaining ability. This makes moisture, both for comfort and for measurement, a very influential element in heat gain. For the design and analysis of air conditioning systems, cooling towers, and industrial processes requiring close monitoring of the vapor content in the air, awareness of a system consisting of dry air and water vapor is important. Fortunately, these interactions can be integrated in a single chart, with air moisture and heat interaction. This rate of water evaporation is solely dependent on the temperature and humidity of the air, as well as the pressure of the position in question. Sweat thus accumulates more on hot humid days in which it is difficult to evaporate the transpiration. In the last few decades, energy demand worldwide for building cooling has risen significantly, raising fears about the depletion of energy supplies and leading to global warming. Estimates of current energy demand are between 40 and 50 percent of total primary energy consumption. Most of the energy used in hot-climate countries is used to cool buildings to sustain air conditioning using conventional HVAC systems.

2. Principles of Evaporative Cooling

It might be best to think of air as being like a sponge or cooling pads when trying to understand evaporative cooling, in that sense the air can absorb moisture that, it comes into contact with. Depending on the condition of the air and the temperature of the air, the amount of moisture the air can consume. If the air is warm and only contains a small amount of moisture, the moisture would be more radially absorbed. Its volumes decrease as the air cools, and with it, its ability to absorb humidity decreases. It is a natural phenomenon to cool by evaporation and the most common thing we all feel is sweat or sweat when sweat evaporates, It absorbs the heat to cool our body. For coolness, It is a heat and mass transfer mechanism that involves water for evaporation in which heat is transferred from air to water and the air temperature decreases at the same time. The idea that water must have heat added to it to transform from liquid to vapor is the concept underlying evaporative cooling. This heat is extracted from the water as evaporation happens and the water stays in the liquid state, resulting in a cooler liquid.

Fig.1.1 Actual Setup

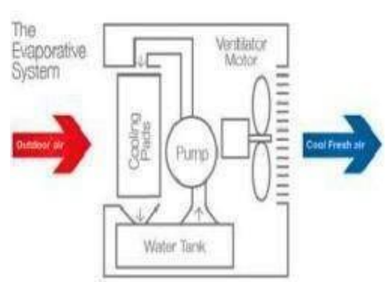

Fig.1.2 Basic evaporative principle

A. Cooling Pads

It might be best to think of air as being like a sponge or cooling pads when trying to understand evaporative cooling, in that sense the air can absorb moisture that, it comes into contact with. Depending on the condition of the air and the temperature of the air, the amount of moisture the air can consume. If the air is warm and only contains a small amount of moisture, the moisture would be more radially absorbed. Its volumes decrease as the air cools, and with it, its ability to absorb humidity decreases. It is a natural phenomenon to cool by evaporation and the most common thing we all feel is sweat or sweat when sweat evaporates, It absorbs the heat to cool our body. For coolness, It is a heat and mass transfer mechanism that involves water for evaporation in which heat is transferred from air to water and the air temperature decreases at the same time.

The idea that water must have heat added to it to transform from liquid to vapour is the concept underlying evaporative cooling. This heat is extracted from the water as evaporation happens and the water stays in the liquid state, resulting in a cooler liquid.


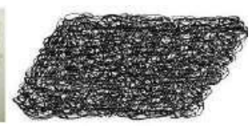

Fig.2 (a) Wood Fibres Fig. 2(b) Aspen Wood Wool


Fig. 2(c) Cellulose Paper Pad Fig. 2(d) Earthen Lamp with POP

3. Experimental Analysis

In a prepared model of a direct evaporative cooler, four different materials from cooling pads are developed and experimentally tested one by one. Including these four styles of cooling pads, the direct evaporative cooler was measured on three separate sides of the evaporative cooler using different cooling pads from the tree. In this way, tests were conducted four times by varying the cooling pads and the temperature and humidity readings were taken. The comparison is given in table 1 between the readings of different types of cooling pads.

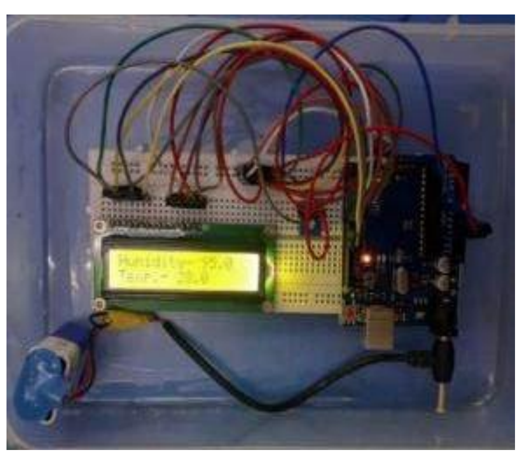

Fig.3 Reading Panel

Table-I: Experimental Readings

Types of Cooling Pad (Material)	Thickness (cm)	DBT inlet (^{o}c)	Humidity initial (%)	DBT outlet (^{o}c)	Humidity final (%)
Aspen wood wool pad	2	30.93	39.66	25.2	79.33
Coconut Coir fibre	2	33.53	38	27.2	68
Combination of two Different pads	2	32.06	44	25.86	86
Earthen lamp With POP	2	32.0	43	25.85	85

The efficiency of a direct evaporative cooler can be calculated as given below, based on the above readings. Considering Earthen Lamp with POP as a cooling pad material.

From the psychometric chart,

For DBT = 28^{o}C and Humidity = 56%,

We get Wet bulb temperature (WBT) = 21 ^{o}C
Now, cooling efficiency is given by,

$$\text{Cooling efficiency } (\eta) = \frac{(t_1 - t_2)}{(t_1 - t_s)} \times 100$$

Where, t_1=Inlet DBT, t_2=outlet DBT, t_s=WBT

Therefore, from the above, the cooling efficiency for Earthen Lamp with POP is 33.33% Similarly, the cooling efficiency for other cooling pad materials can be found.

4. Results

The comparison of cooling performance outcomes for different types of cooling pads is shown in Table 2.

Table-II: Comparison of Cooling Efficiency

Cooling Pad Material	Cooling Efficiency (%)
Aspen wood wool pad	57.12
Coconut Coir fibre	55.6
Combination of two Different pads	64.37
Earthen lamp with POP	64.5

5. Conclusions

Use of an earthen lamp and POP for evaporation purposes, resulting in a decrease in air temperature which also contains the most cost-effective environmentally friendly device. Methods are studied for commercial and comfort purposes in this paper on evaporating cooling technology. In observation, the number of cooling materials from which we find earthen lamp and POP are most successful is taken. It offers improved cooling, as well as this material's life cycle, which is also higher than other materials. A greater area for evaporation and therefore better cooling is given by the curved surface of the earthen lamp.

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