Experimental Investigation on the Performance of Modified Air Cooler

Sumit S. Kalmegh[1], Sumit S. Jamkar[2], Sachin S. Ingole[3] and Gajanan D. Mandavgade[4]

[1,2,3&4]*Sipna College of Engineering & Technology, Amravati (M.S.), India*

[1]*sumitkalmegh20@gmail.com*,[2]*jamkarsumit@gmail.com*,[3]*ssingole1971@gmail.com*,[4]*gajananmandavgade47@gmail.com*

Abstract: *In the Vidharbha region of Maharashtra, India, the months of June and July are typically very important because the high relative humidity and dry bulb temperature are uncomfortable for people. The "Modified Air-cooler" was developed in an effort to meet human needs while taking into account comfort and affordability. Modified air-cooler testing has been done as part of an exploratory inquiry. It has been noted that the DBT values for indoor and outdoor environments vary by 2.86°C on average. As a result of the mud pot's natural evaporation process, the temperature inside the room is cooled more effectively than it is outside. Additionally, the WBT measurements for indoor and outdoor conditions vary by 2.62°C. It has been noted that there is a 2.2% variation in relative humidity when compared to the outside environment, which suggests that the current system is not responsible for the increase in humidity that occurs in the month of June and July, also the system is not contributing in global warming which is a major findings of this research.*

Keywords: DBT, WBT, Relative humidity & Human comfort

1. Introduction

There are numerous applications for the phenomenon of evaporative cooling, including the metabolic control of human body temperature by sweat evaporation from the skin, the use of cooling towers or evaporative condensers, and the cooling of swimming pools through water evaporation. In addition, before the concepts of refrigeration by mechanical compression or absorption were developed, it was the most widely used technique of cooling the atmosphere in ancient times. A way to get rid of heat is via cooling using air. It functions by increasing the surface area, the airflow over the object to be cooled, or both. The industry standard for system cooling, air cooling dissipates heat. The entire area surfaces of the objects have been cooled using external devices like fans and other heat sinks. It goes quickly and requires very little time. There are more benefits than with liquid[1] cooling. Currently, it is Dr. Donald Pescod's research that has developed various studies on plate evaporative coolers, using plastic materials for the plates and creating artificial turbulence to minimize air film quiescence. We performed pioneering research to realize a very high heat transfer area with a low heat distribution and a compact distribution. The main resistance to heat transfer through air is on the dry side of the system, so the advantage of high thermal conductivity of metals compared to plastics is negligible. In addition, the plastic avoids corrosion and is well able to withstand the high pressure differentials characteristic of this type of equipment.

Corresponding Author- Sumit S. Kalmegh*

In the 80s, interest in these systems increased significantly, with numerous articles and communications in scientific journals researching various applications of this technology, such as the recovery of the energy associated with the flow of return air from refrigerated spaces was developed.

Evaporative cooling is a heat and mass transfer process based on the conversion of sensible heat into latent heat. Unsaturated air lowers the temperature and provides sensible heat that is converted to latent heat to evaporate water. If this process proceeds under ideal adiabatic conditions, the dry-bulb air temperature will decrease and humidity will increase during this transformation. This heat exchange continues until the air reaches saturation. At this time, the air and water temperatures reach the same value, called the "adiabatic saturation temperature". This process is called "adiabatic saturation". To define this temperature, we can imagine a long insulated tunnel into which moist air is introduced under certain conditions. Meanwhile, water is sprayed into the tunnel and circulated to saturate the air. In practice, water in tanks, pumps and pipes is usually subjected to sensitive external loads. Furthermore, the temperature of the water supplied for supporting and purging the evaporative section does not necessarily correspond to the adiabatic saturation temperature of the intake air. Therefore, the concept of "adiabatic saturation" in evaporative cooling processes is only a theoretical limit to which the water or air involved can be cooled ideally. When the water temperature is well above the adiabatic saturation temperature of air, the process is similar to that of a cooling tower, cooling air and water simultaneously.

2. Literature Review

Yadav J. P. et al. [1] have published a complete set of numerical parameter studies on automotive radiators and are described in detail in this study. Radiator modeling is described using his two methods. One uses the finite difference method and the other uses the concept of thermal resistance. In performance evaluation, the chiller is installed in a test rig and various parameters such as refrigerant mass flow rate and refrigerant inlet temperature are evaluated. And so on. A comparative analysis between different coolants is also presented. One coolant as water and other as mixture of water in propylene glycol in a ratio of 40:60 is used. Water is still observed to be the best coolant, but the limitation is that water is corrosive and contains dissolved salts that impede coolant flow. Patil C. R. et al. [2] Environmental impacts associated with the use of conventional fossil-based energy, leading to the need to reduce energy consumption and maintain current goals and needs of each energy use activity towards non-renewable resources. Energetic and economic dependencies are presented. Energy increase requires energy. Evaporative cooling is a ubiquitous process in nature, and its application for cooling air has been used since ancient times. In fact, this objective is simply based on the phenomenon of temperature reduction due to evaporation of water and is therefore achieved with low energy consumption compared to the primary energy consumption of other means of cooling. This method could be an interesting alternative to conventional systems in applications where very low temperatures are not required, such as summer air conditioning. This article examines different types of direct and indirect cooling methods in order to understand the different possibilities of cooling by these methods and to offer alternatives. Khobragade N. N. et al. [3] proposed experimental performance of evaporative cooling pads made of different materials was conducted based on meteorological data from Vidarbha, India. We measured the saturation efficiency and cooling capacity of a 4 inch thick cooling pad material. The effects of air and water flow rates on saturation efficiency and cooling capacity were studied for different cooling pad materials such as cellulose, coxgrass and wood wool materials. Saturation efficiency and cooling capacity are calculated for air flow rates of 0.25 to 0.45 m3/s and water flow rates of 60 to 100 cc/hr. Saturation efficiency and variation in cooling capacity with water and air flow rates are plotted for various pad materials. It is observed that the cellulose material has the highest saturation efficiency of about 92.8% and the couscous material has the lowest saturation efficiency of about 40.13%. Cooling capacity increases with air throughput and ranges from 1.1 to 6.72 kW for various materials. Evaporative cooling, studied by Viragade Suraj G. et al. [4], is an energy efficient and environmentally friendly air conditioning technology. Evaporative cooling has many advantages over other cooling methods. Because it is environmentally friendly. It is considered one of the best ways to cool your workplace or living space because it uses fresh air and occasional air changes to maintain room temperature. Circulating air drives out odors and allergens. It is based on the natural process of air cooling by water. It does not dry the air and does not irritate human skin, eyes and other external parts of the human body. Moreover, evaporative cooling is a cost-effective cooling option that improves people's lifestyles. However, evaporative cooling requires large amounts of water and is efficient when relative humidity is low. Experimental and theoretical research work on feasibility studies, performance testing and optimization, heating load calculations are considered and checked in detail. We are constantly striving to achieve saturation efficiency at the optimum water consumption rate. Feasibility of evaporative cooling in different climatic zones, efficiencies of different evaporative cooling devices, key parameters and techniques for improving efficiency, numerical modeling of evaporative cooling processes.

Huang Xiaoqing et al. [5] this paper studies the heat and mass transfer characteristics of corrugated plate spray humidification air coolers as a new air cooling technology under wet working conditions. In terms of the air cooling effect, the spray cooling characteristics comparisons of the same nozzle under different layouts are made. The TF6 nozzle spray with a layout of 500 mm x 500 mm is adopted as the optimal working condition for the heat and mass transfer characteristics. The experimental data under wet working conditions are fit on the basis of the corrugated plate heat exchanger resistance and heat transfer characteristics under dry working conditions. The results show that the spray increases the LMTD of the corrugated plate heat exchanger and significantly increases the air side heat transfer coefficient without jamming the air side runner or increasing the air resistance. Kalmegh S. S. et al. [6] experimentally investigated cooling on vaporizing be the most primitive methods used by human being for chilling their residents. Now it’s been placed on noise footing thermodynamically. It is a method of adiabatic infiltration of air while a squirt of water converted to evaporate interested lacking transfer of heat from or toward surrounding. Despite of some limitations evaporative cooling will produce a condition well within the summer comfort zone. Generally human being feels comfortable when desiccated bulb heat is within 22^0C to 25^0C and comparative moisture is within 55% - 60%. Modifying the existing evaporative cooler some experimental examination is carried out. Result shows that the DBT is reduced by 13^0C; relative humidity maintained in range of comfort zone i.e. 56 % and evaporative cooling efficiency of cooler is improved up to 55% when compared with summer outdoor conditions in Vidarbha (Maharashtra, India) region.

3. Description of Experimental Set-Up

The main component is the radiator having dimension 190x140x25 mm made up of aluminium of 3 liters water storage capacity. A fresh air fan having diameter 12 inches is installed behind the radiator which covers most of the area. A proper spacing is provided between radiator and fresh air fan so that inlet and outlet hose pipe can be installed easily. This set up is enclosed in the MS frame structure having dimensions 20.5x15.5 inches. GI sheet is bolted to the frame so that air loss and vibrations will be eliminated. Below radiator assembly a separate MS frame having height of 3 feet is attached by means of electric arc welding process. So that mud pot can be installed in it, the reason behind using lower frame attachment is make air conditioner system integrated and compact. Two separate SS wire mesh is bolted on front side of radiator and rare side fresh air fan, so that foreign particles, dust, dirt will not enters into the system. A submersible pump is installed in the mud pot for cold water circulation to inlet.

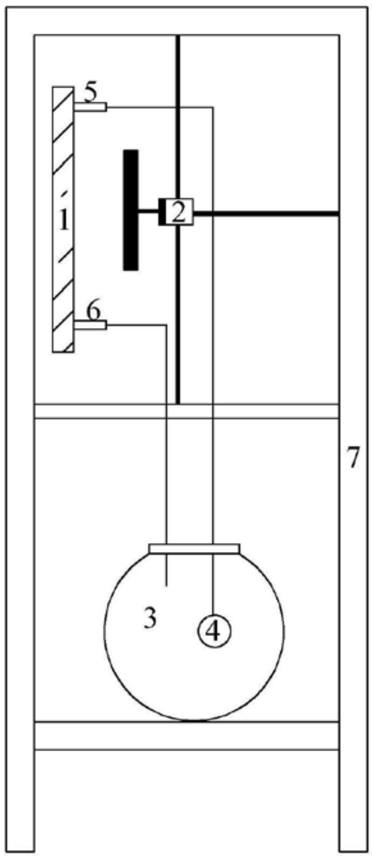

Figure 1. Schematic of experimental set-up (1) Radiator, (2) Fresh air fan, (3) Mud pot, (4) Submersible water pump, (5) Inlet pipe, (6) Outlet pipe, (7) Supporting structure

4. Working Principle

In the radiator, the water which is cold due to natural evaporation in mud pot flows from the inlet to the outlet through many tubes mounted in a parallel arrangement. The cold water enters the radiator through the inlet port and a fresh air fan is attached behind the radiator to blow cool air through tubes. The aluminum fins are attached to the tubes this is called as tabulator. The tubes are filled with cold water coming from the mud pot through submersible pump. Now this cold air enters into the room which will provide cooling effect inside the room.

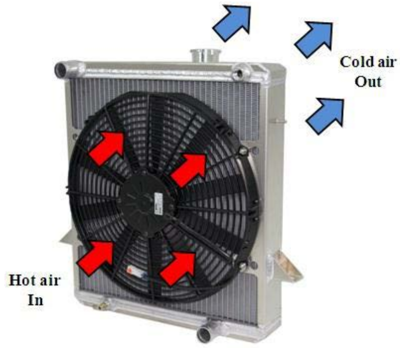

Figure 2. Working principle of modified air cooler

5. Experimental Procedure

Fill the mud pot with water and turn on the submersible pump. Plug in the power cord and connect. Make sure the water circulation through the radiator is working properly and start the outside air fan. Please wait for a while until it reaches a steady state. First, use a thermometer to periodically measure DBT, WBT, and relative humidity every hour with the help of hygrometer. Records DBT, WBT and relative humidity readings for outdoor and indoor conditions. Check the water level at the start and end of operation to check water usage.

6. Result and Discussion

The experimental investigation has been carried out in the month of June & July (between 12:00 noon to 4:00 PM) and result obtained are discussed below.

Table 1. Reading of DBT, WBT and RH for variable time

Sr. No.	Time (pm)	Condition	DBT (℃)	WBT (℃)	RH (%)
1	12	Outside	32.4	28	71.5
		Inside	29.5	26	75.7
2	1	Outside	32.5	28.5	73.9
		Inside	29.7	26.2	75.8
3	2	Outside	33.5	29.7	75.5
		Inside	30.5	26.5	73
4	3	Outside	34	30.2	75.7
		Inside	31.4	27.5	74
5	4	Outside	34.5	30.5	74.7
		Inside	31.5	27.6	74

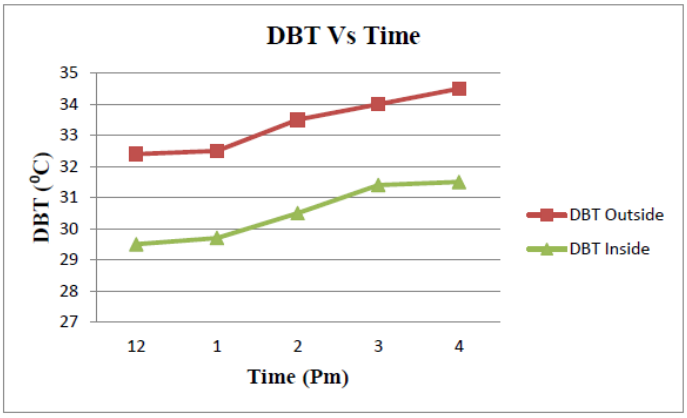

Figure 3. Dry bulb temperature (DBT) versus time

From Fig. 3 and 4, it can be observed that the DBT values fluctuate over a range of 2.86°C for outdoor and indoor conditions. WBT values for outdoor and indoor conditions vary over a range of 2.62°C. This temperature drop is due to the natural evaporation that occurs within the mud pot, resulting in better cooling of the room compared to external conditions.

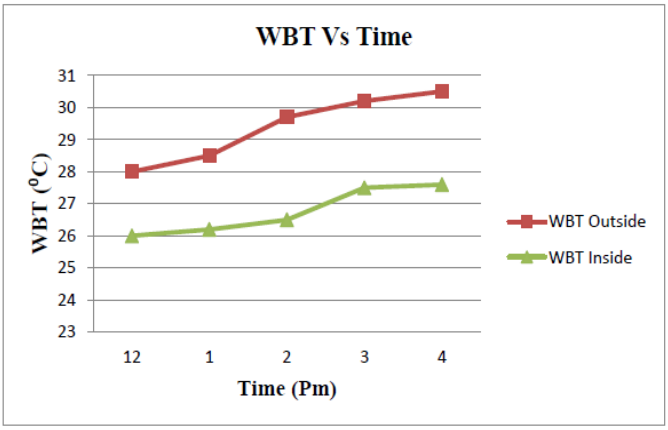

Figure 4. Wet bulb temperature (DBT) versus time

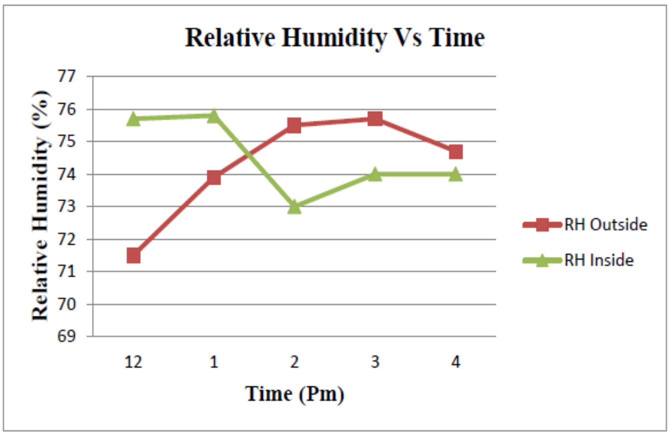

Figure 5. Relative Humidity (RH) versus time

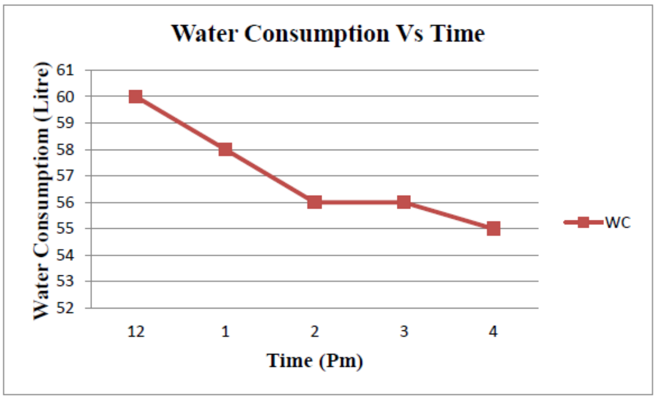

Figure 6. Water Consumption (WC) versus time

From Fig. 5 and 6, we can see that the variation in relative humidity compared to outdoor conditions is in the range of 2.2%. This indicates that the existing system did not contribute to humidity rise, which is a major advantage of this system. Existing systems are low on water consumption, using only 3-4 liters of water for indoor cooling effect.

7. Conclusions

The DBT, WBT, and relative humidity values differ by 2.86°C, 2.62°C, and 2.2% for indoor and outdoor settings, respectively. As a result of the mud pot's natural evaporation process, the temperature inside the room is cooled more effectively than it is outside. The main advantage of this system is that it does not contribute to the increase in humidity in the month of June and July. The system is also advantageous in terms of water usage. The amount of water used to provide cooling for the space was only 3–4 litres. The system is not contributing in global warming which is a major finding of this research.

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