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Performance Evaluation of Evaporative Cooler using Luffa Fiber Materials

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***Abstract*—The purpose of this study was to evaluate the performance of two different agro-based cooling pad in various thickness, experiment investigation of a direct evaporative cooler in hot and humid regions. We have experimentally examined the change of cooling pad thickness, air velocity, water flow rate, static pressure drop across pad. The test were carried out at the different size cooling pad (40, 80,120, 160 mm) for the locally available of two different materials name luffa, zizanoiddes .The performance of the evaporative cooler is evaluated using the output temperature. A test rig was designed and fabricated to collect experimental data. The analysis of the data indicated that cooling saturation efficiency improve with decrease of air velocity and higher pad thickness. The results were compared with two different locally available materials. It was shown that zizanoides agro based pad with 160mm thickness has the higher performance (88%) at 2.2 m/s air velocity in comparison with luffa fiber pad materials.**

Keywords*— Desert cooler, NaturalEvaporative media, Perofrmance, Luffa, zizanoides,Effectiveness

I. INTRODUCTION

Evaporative cooling is the process in which sensible heat is removed and moisture is added to the air. As the air passes through a wetted surface, it gives up heat to the water. Some of the water from the wetted surface evaporates and pick-up heat from air equivalent to it is latent heat. The vapors thus formed are carried along in the air stream. In this system, the air is cooled and humidified.

Evaporative cooling process remains one of the least expensive techniques, environmentally clean, fresh supply air and natural fragrance of air, to bring dry bulb temperature to a more comfortable range, during hot season since ancient time. Chung –min-et al [2]. The principle of evaporative cooling indicates that the evaporative cooling system can only remove room sensible heat. Thus the evaporative cooling system works hot and dry climates where the maximum evaporative cooling will result. Ghasem Hei-et al [1] cooling the air by evaporation of water is an environmentally clean energy efficient method for cooling building evaporative air conditioning (EAC) technology are being used increasingly in residential and commercial application worldwide. EAC technology which relies on water as a coolant rather than on chemical refrigerants is economical to produce and use and have important environment benefits. air cooling provides superior indoor air quality in comparison with vapor comparison systems since fresh outdoor air is used Vivek.w.khand et al [3] evaporative cooling has many benefits and advantages over other forms of cooling. It is one of the healthiest ways to cool your home because it uses clean fresh air to replace the air in your home many time an house .the air inside your house is never re-circulated which means that smells and allergens are expelled based on a totally natural process of air cooled by water means it won’t dry out the air or irritate your skin, throat or eyes. Doors can be left open allowing you to enjoy the summer and an outdoor life style. Evaporative cooling is also an inexpensive cooling option. It is up to 50% cheaper to install and seven times cheaper to run than refrigerated cooling. Since evaporative cooling uses less electricity than other forms of cooling. It is kinder to our environment as its green house gas contribution.

Evaporative coolers have been widely used in many arid areas of the world such as south western, United States, Australia and western Asia [5] Lioa-chin- et al. Researchers used different methods to increases the cooling in recent years. Masha barzegar et al [4] the method include changes of air velocity, mass flow rate of feed water, dry bulb-temp, static pressure drop, pad thickness, genus, geometric structure of pad, quality of feed water and modification evaporative cooling structure. Dai and Sumathy et al [6].studied cross flow direct evaporative cooler in which the wet durable honeycomb paper constituted as the packing materials .they found that the lowest temperature ever achieved and the system performance can be further improved by optimizing the operation parameters such as the mass flow rates of feed water and process air as well as the different dimensions of the honey combed paper. Chung-min-liao et al [2] generally higher efficiency are obtained with thicker pads ,and slower air velocities the results reflect grater evaporative as air takes more time to travel through the pad. Therefore, the amount of time allowed for the pad to reach equilibrium with room air condition between test increments to be indicated, greater pressure drop are obtained with thicker pads. Kachwaha and Suhas et al [7] designed fabricated and predicted the performance of an evaporative medium the pad thickness and height were achieved for maximum cooling. Al-sulaiman et al [8] has evaluated the performance of the natural fibers. Palm, Stems, Jute and Luffa. The result indicated that luffa has an overall advantage over the other fibers. Khond .wv. et al [9] evaluated the performance analysis of desert cooler by using stainless wire mesh pad ,coconut coir pad, Khus pad, and wood wool pad, these pad were compared in terms of cooling efficiency. The maximum and minimum cooling efficiency were found in wood wool pad, and Khus pad respectively. Wu-et al [1] discussed the effect of the air frontal velocity and pad thickness on the cooling efficiency of a direct evaporative cooler an optimum frontal velocity in 2.5m/s was

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recommended to decide the frontal area of pad in the given air flow. Chung-min [2] the commercial pad materials are usually complicated to manufacture and they are costly and not readily available therefore there is need to evaluate the locally availably materials for use as pads. Particularly rural agricultural areas, Mathews et al [11]. Aballa et al [12]. Lioa.et al [13]. And Zivanal et al [14] suggested that alternative pad media such as gourd stem sponge, jute fiber, charcoal, nylon, and coir fiber can expose maximum surface area of water to the passing air flow with help of forced or natural ventilation and the cooling efficiency up to 85-90% could be reached for all the above materials.

In this paper the performance of two different agro-based materials namely luffa and ziznoides, are evaluated experimentally to obtain the fundamental design information on the influence of air and water flow velocity on the heat and mass transfer co-efficient for the evaporative process through various thickness of alternative pad media (40, 80, 120 and 160mm) the effects of alternative pad designs related with saturation efficiency, face velocity and static pressure drop across the pads, water consumption, and cooling capacity are investigated.

II. MATERIALS AND METHODS

A. Materials and Experimental Setup

In psychrometric process, dry air considered single gas. In this work, humid air is considered as mixture of two gases (dry and water vapour). Heat transfer will occur between cooling pad wet surface and humidity air flow close to a wet surface.

The experimental desert cooler unit consists of rectangular (300x450mm) and 3m long. It is made up of acrylic sheet for easy viewing. It’s contains large vertical filter (250x300mm) pads. An electric motor driven axial type blower is used as a water pump as water distribution system. A drainage section was provided at the bottom of the unit in order to drain the water during the experiments into a sump. The sump was made by transparent glass (900x300mm) and 250mm height and water was dispensed over the pad by one tube which was installed on the top of the pad. Tubes had several nozzles to supply water uniformly over pad medium. A schematic of the experiment set up is shown in Fig.1. The unit of measurements and their accuracy are shown in Table.1.

TABLE I. INSTRUMENT AND THEIR DETAILS

Parameter	Unit of Measurement	Accuracy	Range
Dry Bulb Temperature, Water Temperature [Chromel-Alumel thermocouples –K typ]	°C	0.1°C	0 -70 °C
Flow rat of water [Flow meter]	lts/hr	0.01	0-1000
Air Velocity [Vane type anemometer]	m/s	0.1	0-50
Air Pressure Drop [U-tube manometer]	mm of water	1mm	0-100mm

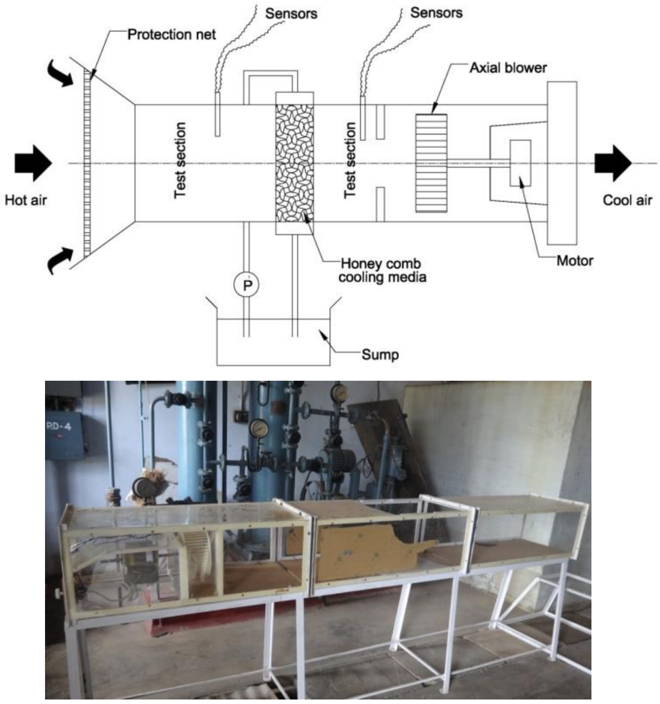

Fig.1. Experimental Setup

B. Measurements and Instrumentation

Experiments tests are carried out to evaluate the performance of the direct evaporative cooling unit. To measure the air relative humidity and temperature at inlet and outlet points of the evaporative cooling unit. Three important measured parameters were water consumption, pressure drop and cooling efficiency for measurement of the temperatures, two thermocouples of type k with a high accuracy was to use measure the temperature. These temperatures were manually recorded at all measuring position during each test. The air velocity was measured by an anemometer. Water consumption was measured by reading from calibrated sump. And water flow rate was measured with aid of bullet type of flow meter. The pressure difference was measured with manually aid of u tube manometer. To measure the relative humidity with aid of hygrometer all instruments were properly calibrated before starting the test. And it is located in right position

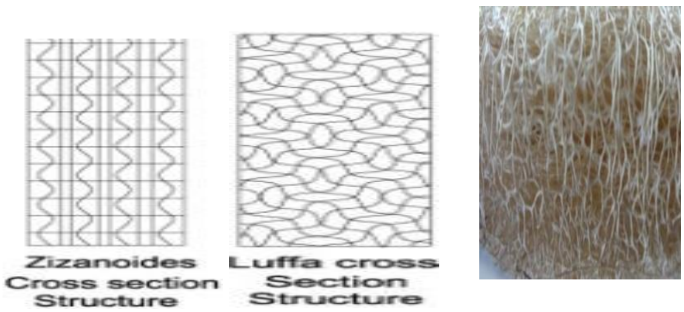

Fig.2. Cooling pad

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C. Performance Parameter

A direct evaporative cooler is a simple air conditioning system widely used and in dry and hot regions the air and water are in direct contact; the hot, dry air passes over a wet pads surfaces, the air will lose its sensible heat, thereby reducing its temperature the performance of direct evaporative cooler are calculated based on the following relation. Abdulrahaman- et al. [15] the saturation efficiency is the rate between the real decreasing of the dry bulb temperature and the maximum theoretical decreases (dry bulb temperature would be equal to the wet bulb temperature of the inlet air) as seen by Camargo et al. [16] and (17). The dry bulb temperature of the outlet air can be calculated by below Equations (1) and (2) are,

$$\varepsilon_{DEC} = 1\text{- Exp } (h_c A_w / m_a C_{pa}) \quad (1)$$

$$T_2 = T_1 - \varepsilon_{DEC} (T_1 - T_{wb}) \quad (2)$$

III. RESULTS AND DISCUSSION

A. The effect of air velocity on cooling efficiency

The values of the experiment test dry bulb temperature of the inlet and out let air, saturation efficiency and pressure drop.

Fig.3and Fig.4 shows the effect of air velocity on cooling efficiency of the two different agro-based materials. The results show that zizanoides materials with 160mm Thickness have the highest – efficiency (89%) at 2.2 m/s air velocity.

It can be observed that the cooling efficiency increases Masha Barzaga – et al. [14] the air velocity decreases, because slower air velocity causes greater evaporation rate as air passes. More time through the Ped dai & sumathy [6]. Gunhan et al. [18]. Also by increasing the air velocity the available time for heat and mass transfer between air and water decreases.

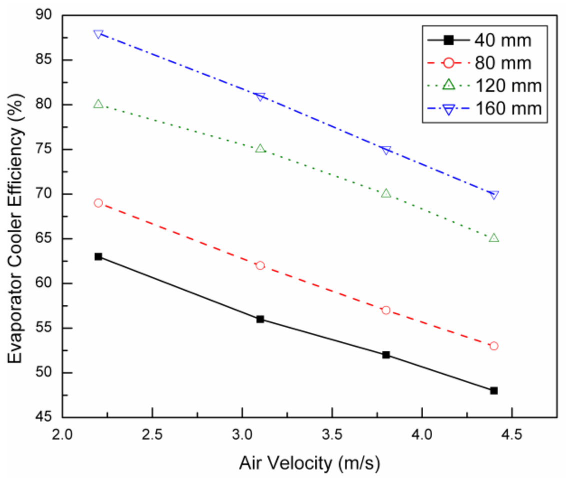


Fig. 3. Air velocity Vs evaporator cooler efficiency

Chung – min – et al (3) Generally higher efficiencies are obtained with thicker pads, and slower air velocities. The results reflect greater evaporative rates as air takes more time to travel through the pad. Therefore the amount of time allowed for the pad to reach equilibrium with room air conditions.

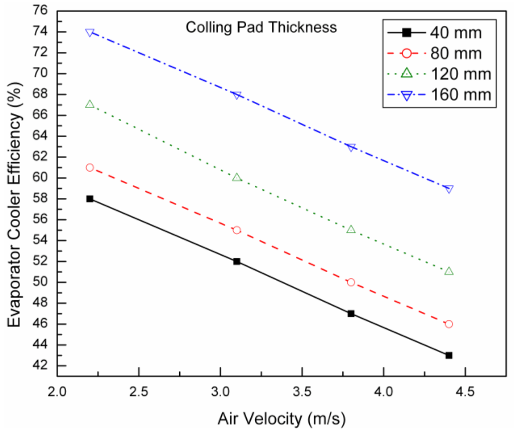


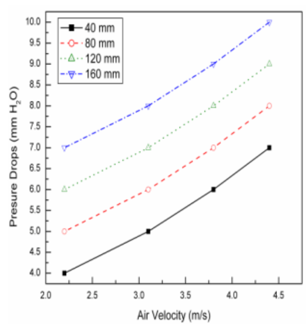
Fig. 4. Air velocity Vs evaporator cooler efficiency

B. The effect of face velocity on pressure drop

Fig.5 and Fig.6 shows the effects of face velocity on pressure drop. Across pads and on cooling efficiency for two different materials luffa, zizanoides shown in the Fig.5, that a pad 40mm, thickness ranged in pressured drop from (4 to 10mm) at face velocity (3.2 to 4.4m/s). A 80mm and 120mm pad has a pressure drop mach closer to a 40mm pad. A 160mm pad operated at a pressure drop more than a 120mm pad the Fig.6 show that a pad 40mm thickness ranged in pressure drop from (3 to 13mm) at face velocity (2.2 to 4.4m/s). An 80mm and 120mm pad has a pressure drop much closer to a 40mm pad. The 160 mm pad operated at a pressure drop more than a 120mm pad.

Experiments results more obtained generally greater pressure drop are obtained with thickness pads. In our study the luffa materials pressure drop higher when compared with zizanoides materials due to many reason the structure, physical properties, porosities, water holding capacity, water flow rate, Increases of air velocity and also affects pressure drop.

The luffa pad material can be found, higher pressure drop since these pad have small fiber air passage therefore air resistance happened so air passes through pad very slowly. The zizanoides pad materials can be found lowest pressure drop since these pads have largest air passage way therefore air passes through the pad highly with low air resistance.



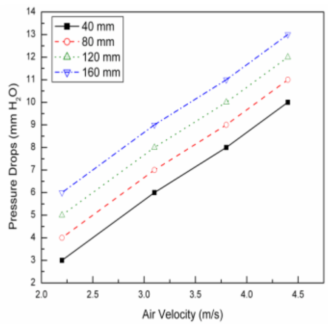


Fig.5. Air velocity Vs Pressure drops Fig.6. Air velocity Vs Pressure drops

IV. CONCLUSION

- In this Experiments investigated that DBT decrees (up to 9°C) is attainable by evaporative cooler during dry and hot season months.
- Using the general approach to evaporative cooling device designed to evaluate the performance of two agro-materials to be used at wetted pads in cooling.
- The chosen materials are luffa, and zizanoides. The performance criteria Include cooling efficiency, air velocity and pressure drop. The results show that the average cooling efficiency is highest for zizanoides (88%) compared (77%) for luffa. At same the velocity and pressure drop is higher for luffa compared to zizanoides materials pad.

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NOMENCLATURE

ε_{DEC}	Evaporative saturation Efficiency in %
A_w	Wetted area in m^2
C_{pa}	Specific heat of air in J/kg. K
h_c	Heat transfer co-efficient in $W/m^2.K$
M_a	Mass flow rate of air in kg/sec.
T_1	Evaporative inlet dry bulb temperature in °C
T_2	Evaporative outlet dry bulb temperature in °C
T_{wb}	Evaporative inlet wet bulb temperature in °C
DBT	Dry bulb temperature