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Experimental Analysis of Coconut Coir Pad Evaporative Cooler

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Abstract: This paper investigates the performance analysis for a new sustainable application to reuse an Coconut Coir fiber, in evaporative cooling pads. Coconut coir pads are fabricated and tested on low cost desert coolers used in this region .Laboratory scale experimental arrangement were made and tested. The coconut coir fiber pad was analyzed and compared with those of a commercial Aspen wood (wood wool) pad. Results show that the coconut coir fiber pad had similar saturation (cooling) effectiveness of near about 60% while the Relative humidity drop was observed from 80-85% of Aspen wood pad to 50-60% of Coconut coir pad. Also the water consumption rate for coconut coir fiber pad is less than aspen wood pad. In addition, the cooling potential of the coconut coir pads was analyzed using the average climatic conditions of Jalgaon (Maharashtra) in India as the temperature in Jalgaon during summer season is near about 40°C to 45°C. The analysis shows that the air temperature leaving the coconut coir pad varied from 27 to 32°C. Commercial development appears feasible given the coconut coir pad's good performance, lower cost and its availability throughout the country. Also the life of Coconut Coir Pad as compared to Aspen Wood pad is more.

Keywords: sustainable application; evaporative cooling pads and coconut coir.

I. INTRODUCTION

The evaporative cooler got popularity and Interest of researchers to various models in the twentieth century; many of these, starting in 1906, with the use of excelsior (wood wool) pads. In 1945 patent [1], a water reservoir (the level of water is controlled by a float valve), a pump to circulate water over the pads and a fan to draw air through the pads and circulate into the house. This is a important design and remain dominant in evaporative coolers in the world.

1.1 basic principles

Evaporative cooling is a physical phenomenon in which evaporation of a liquid into surrounding air. The evaporation of liquid takes place by absorbing latent heat drawn from the air. To find water evaporated into air, the dry bulb and wet-bulb temperature is to be measured to determine the potential for evaporative cooling. The evaporative cooling effect is greater when the differences between the two temperatures are greater. When the both the temperatures are the same, net evaporation of water in air doesn't occurs, thus there is no cooling effect refer fig.1.

A natural evaporative cooling is also called as perspiration, it secrets from body to cool itself. The heat transfer from the body depends on the evaporation rate of water (Enthalpy of vaporisation for water at 36°C is 2257 kJ/kg). The rate of evaporation depends on the temperature humidity of the air. Hence sweat accumulates more on hot, humid days and the perspiration cannot evaporate.

1.2 Types of systems

The evaporative cooling is done in various stages is mentioned as follows:

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1.21 Single Stage / Direct

Single-stage (direct) evaporative coolers, it consists of water tank, blower, hydraulic pump, cooling pads and other components are like metal frame etc.. Water is circulated by the pump from a tank over the cooling pad, and the blower draws in outside hot air, which passes through the moist pad and supply to space to be cooled into the building. Water lost in the tank through evaporation is again filled externally. The direct evaporative cooling process is illustrated in Fig.2 Some single stage coolers uses rotating cooling evaporative pads through a water bath in such coolers pump is not required.

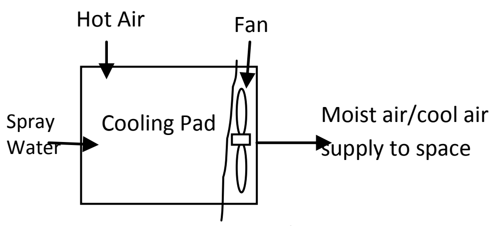

Fig. 1 Basic principle of evaporative cooling

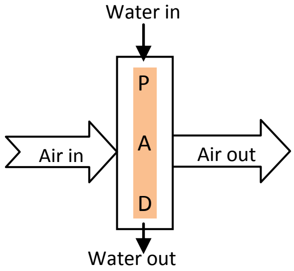

Fig. 2 Single Stage/ Direct air flow system

1.22 Two-Stage Systems

Two stage- Indirect/Direct air flow evaporative coolers in which an indirect cooling stage upstream of the direct stage is added. In the indirect stage air-to-air heat exchanger, cools the outdoor air by evaporative cooling, without moisture addition (Fig. 3) Two stage systems deliver cooler and drier supply air , but at the expense of some added fan and pump energy. Indirect-only evaporative coolers are sometimes used to pre-cool make-up air for larger commercial buildings, but are not addressed by this proposed standard. There are currently two, two-stage products on the market. Performance of two-stage systems can be characterized either by their indirect and direct effectiveness or by an overall evaporative effectiveness for the two stages. Overall effectiveness can be used to compare single and two-stage systems and is a preferred metric for standards purposes.

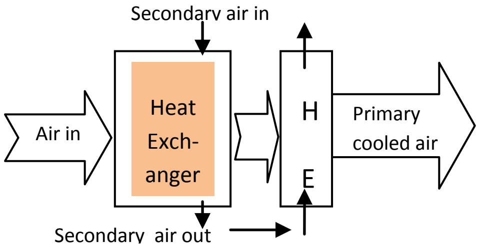

Fig. 3 Double Stage- In Direct/direct air flow

1.23 Evaporative cooling pads

Cooler effectiveness depends largely on the capability of the evaporative pads or "media" to provide a high wetted surface area and minimal airflow resistance. Many materials have been used for evaporating media as natural and synthetic fabrics.

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Type	Material
Synthetic	Expanded paper, and woven plastic.
Natural	wood excelsior, aspen pads, cellulose.
Matellic	copper, bronze or galvanized screening; vermiculite, perlite.

II. LITERATURE SURVEY

The researches views are introduced as J.M. Wu, X. Huang, H. Zhang(1), In this paper Theoretical analysis to the heat and mass transfer between air and water film in a direct evaporative cooler with wet durable honeycomb papers constituting the pad modules is carried out. Y.J. Dai, K. Smith (2),The characteristics and the performance of a cross-flow evaporative cooler using honeycomb paper as packing material have been studied. Under typical conditions, it can reduce the air temperature by 9^{o}C and increase the humidity ratio by about 50%. The minimum air temperature can be obtained at the length of the air channel to be about 5–10 cm. Zhang Qiang , Liu Zhongbao, Yang Shuang, Ma Qingbo(3), has described the experimental and theoretical analysis of a TSEC unit is done. The outlet air temperature drop by the two-stage evaporative cooler depends on inlet air wet bulb temperature, secondary air relative humidity and packing thickness of DEC.R. Rawangkula et.al (4), reports a performance analysis for a new sustainable engineering application to beneficially reuse an abundant agricultural waste, coconut coir (Cocos nucifera), in evaporative cooling pads. Ghassem Heidarinejad et.al (5), this paper show that under various outdoor conditions, the effectiveness of IEC stage varies over a range of 55–61% and the effectiveness of IEC/DEC unit varies over a range of 108–111%. J. Khedari et.al (6), This research was aimed to investigate the feasibility of using dried agricultural waste as desiccant for an open cycle AC system. The natural fibers are used with a intention to replace chemical desiccant such as silica gel etc.. The investigation was limited for Coconut coir (Cocos nucifera) and Durian peels (Durio zibethinus). R. K. Kulkarni and S. P. S. Rajput (7), This paper analyzes the performance of jute fiber ropes that are used in the form of rope bank as wetted media in evaporative coolers. R. Rawangkul, J. Khedari, J. Hirunlabh and B.Zeghmati (8), The objective of this study is to develop a moisture adsorption isotherms model of Coconut coir (Cocos nucifera) and to simulate long term performance of this material as desiccant under Bangkok ambient conditions.

It is observed that Young coconut coir reveals the average moisture adsorption capacity is about 26% dry basis at the average air relative humidity and temperature of about 73% and 28.6^{o}C, respectively. The maximum moisture adsorption capacity is 37% when air relative humidity is 80%.

After referring above researches we can conclude that the best and optimize air cooler can be developed using the evaporative media

a)Aspen Wood, b) Coconut Coir

III. DISCUSSION OF OBJECTIVE

The outside when thermometer is open to sun temperature in march ranges from 38-42 °C. How much we are away from comfort zone & How and upto what level we can achieve this comfort zone.

The below mentioned data reveals the relation of DBT & RH of Jalgaon be used to analyse our work: At DBT 32 °Cand 15% relative humidity, air may be cooled to nearly 16 °C. The dew point for these conditions is 3 °C. At 32 °C and 50% relative humidity, air may be cooled to about 24 °C. The dew point for these conditions is 20 °C. At 40 °C and 15% relative humidity, air may be cooled to nearly 21 °C. The dew point for these conditions is 8 °C. As shown in figure:4. As Point“1,2and 3”t.

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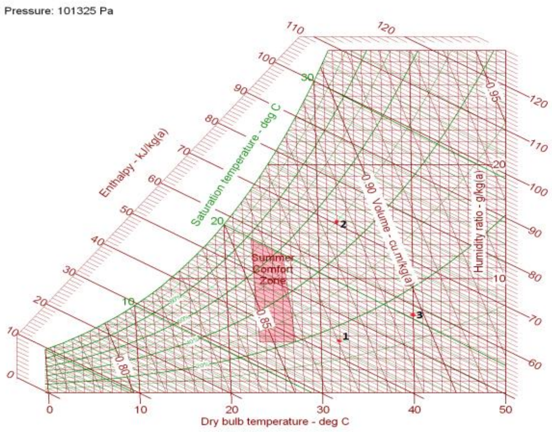

Fig. 4 Comfort zone in Summer Season

IV. EXPERIMENTATION

The experimental test rig of low cost desert cooler available in market is tested in laboratory at various different conditions. The desert cooler with aspen wood pad and with coconut coir pad is tested separately. The aspen wood pads are tested as per standards available in the market but coconut coir pads of different thicknesses are made for testing purpose .The pads thickness varies from 2cm to 7cm.

The effectiveness of EVC

$$\eta = (t_{d1} - t_{d2}) / (t_{d1} - t_{wb}) \qquad \text{....eq 1}$$

Where,

T_{d1} =inlet air dry-bulb temperature (°C).
T_{d2} =outlet dry-bulb temperature (°C).
T_{wb}= wet-bulb temperature of the inlet air(°C);
η =evaporative saturation efficiency (%).

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Fig. 5 Test rig of Evaporative cooler

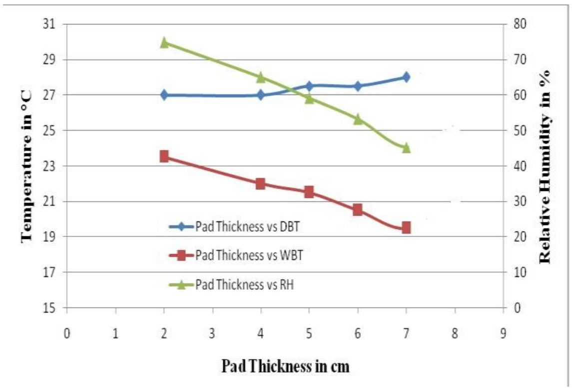

Fig. 6 Performance of coconut coir at 2.00pm

The actual conditions of coconut coir pad at various thickness refer fig.6.

V. RESULT AND DISCUSSIONS

The better performance for the 7 cm pad thickness as the comfort zone in summer season lies between the relative humidity 30-65% and DBT between 23-27 °C. refer fig 6. The performance analysis of Aspen wood pad and Coconut Coir Pad on different days having approximately same environmental conditions. The water consumption for coconut coir is significantly lesser than Aspen wood. The saturation effectiveness range from 36.84 to 57.89 % for coconut coir pad(7cm) and range from 55.56 to 91.67% for Aspen wood(regular size available in market) which shows that the saturation effectiveness for aspen wood pad is more than that for the coconut coir pad. The outside DBT for both the Aspen wood as well as coconut coir pad is near about same i.e. 36-38 °C. The inside DBT varies from 26 to 31ºC and from 27 to 30ºC respectively. This shows that the inside temperature for aspen wood pad is lower than that of coconut coir pad. Thus the cooling efficiency is more for aspen wood pad than coconut coir pad.The inside WBT for Aspen wood and Coconut coir varies from 19.5 to 25ºC and from 18 to 21.5ºC respectively. This shows that WBT achieved for coconut coir pad is less than that for aspen wood pad. The inside relative humidity for Aspen wood and Coconut coir varies from 45.76 to 85.18% and from 30.16 to 61.84% respectively. This shows that relative humidity is too much less for coconut coir pad than of aspen wood pad. The condition of coconut coir pad gives the result in the comfort zone suitable to human body and decreases the suffocation in the room when the evaporative cooler is fitted outside the room. The result shows that water consumption rate of coconut coir pad is too much less than the aspen wood pad due to less humidity and contain less moisture. And the result shows that water consumption rate of aspen wood pad is too much high than the coconut coir pad due to high humidity. As the water consumption rate for coconut coir pad is less, thus the moisture content in the pad will also be very less. This gives the low relative humidity. In aspen wood pad, the water in the pad soaked which creates more moisture content in the pad, which gives more relative humidity.

VI. CONCLUSION

The experimental investigations reveals that coconut coir has reasonable potential for use as a media in evaporative cooling systems. Coconut coir fibre pad when compared to available aspen wood pad, it is found that coconut coir fibre pad had similar saturation (cooling) effectiveness, about 60%, but relative humidity of coconut coir pad is less (40-60 %) than aspen wood pad (70-90%). also water consumption rate for coconut coir pad is less than aspen wood pad. The accuracy of the measurements is considered to be satisfactory based on the measurement of wet bulb temperature, dry bulb temperature, & relative humidity. More specific work can be done Finally, the above result show that natural and cheap materials, such as coconut coir fibre, can be used as a alternative material for rigid media pads.
For the future modifications the density and mass of the coconut coir pad can be reduced.

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