Experimental Study on the Palm Fiber using as a Direct Evaporative Cooler Pad

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Abstract-- **The palm fibers are suggested as a direct evaporative cooler pad instead of rice straws that widely used in commercial coolers. In hot and dry climates such as Aswan city, the palm trees are widely planted while the rice trees do not. Experiments are made to determine the suitable thickness and mass per unit volume of the fiber palm pad. Temperature and relative humidity exit from cooler are measured at different thicknesses and masses of palm fibers. A comparison between optimum selection of palm fiber (t = 6 cm, M/V= 40 kg/m^3) and standard commercial rice straws are made. The results indicate that, the outlet temperature of both palm fiber and rice straws are the same. Cooler effectiveness of palm fiber is higher than that of rice straw at most working ambient temperatures (32^o – 38^o). The relative humidity is lower than that of rice straw with 13% in average. Therefore, the local material, palm fibers, can be used successfully instead of standard commercial rice straws.**

Index Term-- **Experiment; Palm fiber; Evaporative system; Air cooler, Temperature, Relative humidity.**

Nomenclature

E	cooler effectiveness (%)
M	palm fiber mass (kg)
RH_a	ambient relative humidity (%)
RH_e	outlet relative humidity (%)
t	palm fiber pad thickness (t)
T_a	ambient or dry-bulb temperature (^{o}C)
T_e	outlet air temperature (^{o}C)
V	palm fiber pad volume (m^3)

1. Introduction

The palm trees are widely planted in Egypt especially in hot and dry regions. Commercial direct evaporative cooler are widely using the rice straws in these regions. Rice trees are not planted in these regions, therefore the palm fibers are suggested to use instead. Palm fibers are versatile and stable which can be processed into various dimensional grades to suit specific applications such as direct evaporative cooler pad. Using the palm fiber does not involve any chemical reaction; hence, the material is clean and non-toxic.

Malli and et al. [1] studied experimentally the thermal performance of two types of cellulosic pads, which were made from corrugated papers. The pads areas are 50 X 50 cm^2 with 7.5, 10, and 15 cm thicknesses. Dai and Sumathy [2] investigated a cross-flow direct evaporative cooler, in which the wet durable honeycomb paper constitutes as the packing material. They have developed a mathematical model, including the governing equations of liquid film and gas phases as well as the interface conditions. Their results indicate that the system performance can be further improved by optimizing the different dimensions of the honeycomb paper. Wu et al. [3,4] used GLASdek7090 papers as a pad material of the cooler with a thickness of 13.8 cm. It made of a special fiberglass with the characteristics of fine wettable, nonflammable, stiffness and durable. They analyzed the influences of the inlet frontal air velocity, pad thickness, inlet air dry-bulb and wet-bulb temperature on the cooling efficiency of the evaporative cooler. Fouda and Melikyan [5] developed a simplified mathematical model to describe the heat and mass transfer between air and water in a direct evaporative cooler. They used modern high efficiency coolers made from aspen has been replaced by engineered, plastic-coated cellulose rigid cooling pads. In their calculations, Sodha et al. [6] have taken the packing factor of the pads (wet surface area offered by the pads per unit area of the pad) equal to 300, which is typical of the pads available on the Indian market. Camargo et al. [7] used an evaporative pad with 61 X 33.5 X 15.2 cm^3, providing about 3.7 m^2 of evaporative surface area per cubic meter of media, providing a wetted area equal to 11.5 m^2 in the pad.

2. Experimental Setup

A metal direct evaporative cooler shown in Fig. 1 is used in the experiments. Three identical pads made from palm fiber shown in Fig. 2, are fastened in the sidewalls and the last side used as an air outlet. The pads areas are 51 X 56 cm^2 with 3, 6, and 9 cm thicknesses. Water is lifted from the basin by a pump and sprinkled to wet the pads.

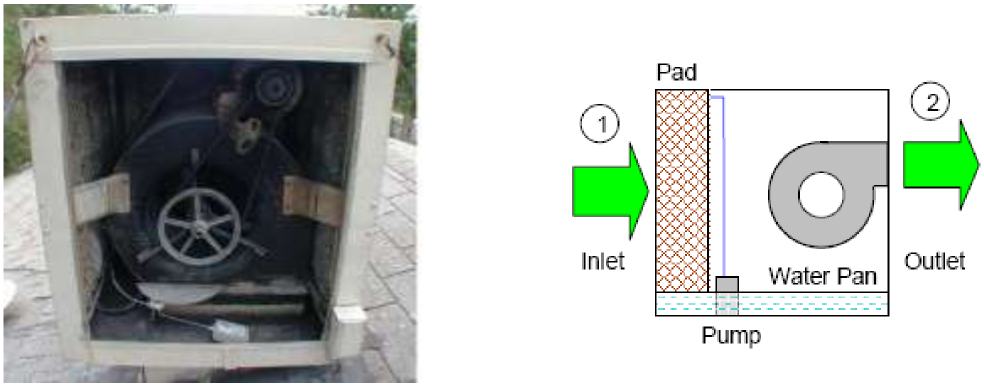

Fig. 1. Direct evaporative cooler

Fig. 2. Palm fiber

3. Experimental Procedures

Palm fibers are fastened on the three sidewalls of cooler by a metal screens. The amount of palm fiber is increased to the maximum value at fixed thickness. The palm fiber mass is well distributed along the area of each face. Exit temperature and relative humidity from the cooler are measured at different masses of palm fiber. Experiments are repeated at different three thicknesses 3, 6, and 9 cm. Commercial rice straw are also used in experiments for comparison. All experiments were almost made at the same ambient temperature and relative humidity.

4. Results

4.1 Effect of palm fiber thickness:

The outlet air temperature and relative humidity are measured with the increase of the weight of palm fiber at three-fixed thickness (3 cm, 6 cm, and 9 cm). As shown in Fig. 3, at the same mass to volume ratio the 6 cm thickness of palm fiber always gives the lowest outlet air temperature up to $M/V = 60\ kg/m^3$. For 6 cm thickness, there is no change in the outlet air temperature when $M/V \geq 40\ kg/m^3$. Therefore, 6 cm thickness with 40 kg/m^3 mass to volume ratio is the best choice to achieve economically minimum outlet air temperature.

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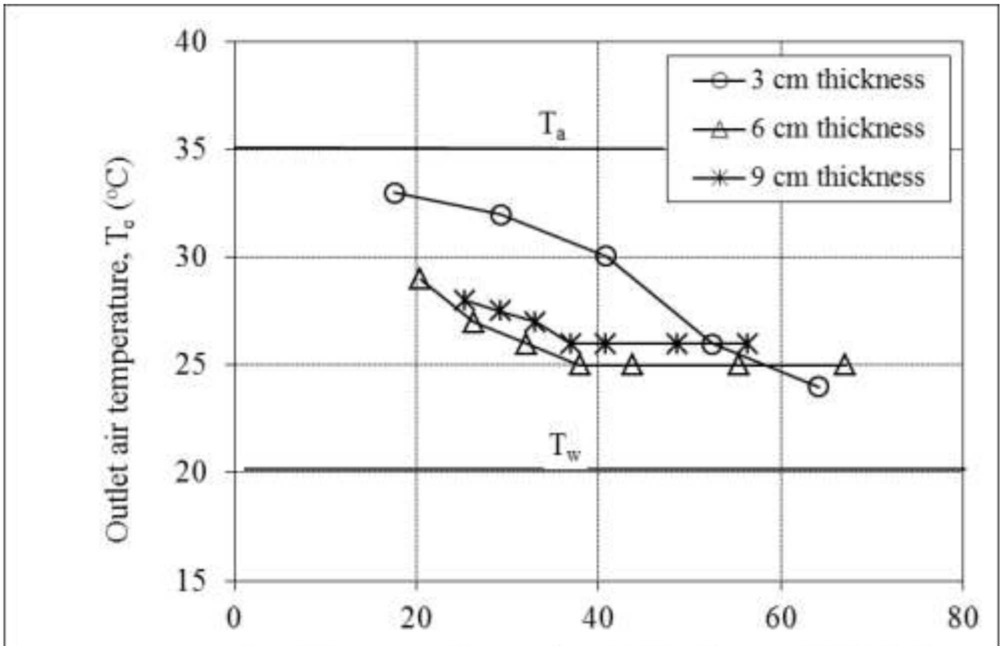

Fig. 3 Mass to volume ratio of palm fiber, M/V (kg/m³)

Fig. 4 shows that the outlet relative humidity increases with the increase of the weight of the palm fiber. However, at 6 cm thickness and M/V = 40 kg/m^3, the outlet relative humidity is approximately 43% which achieves a very comfortable condition.

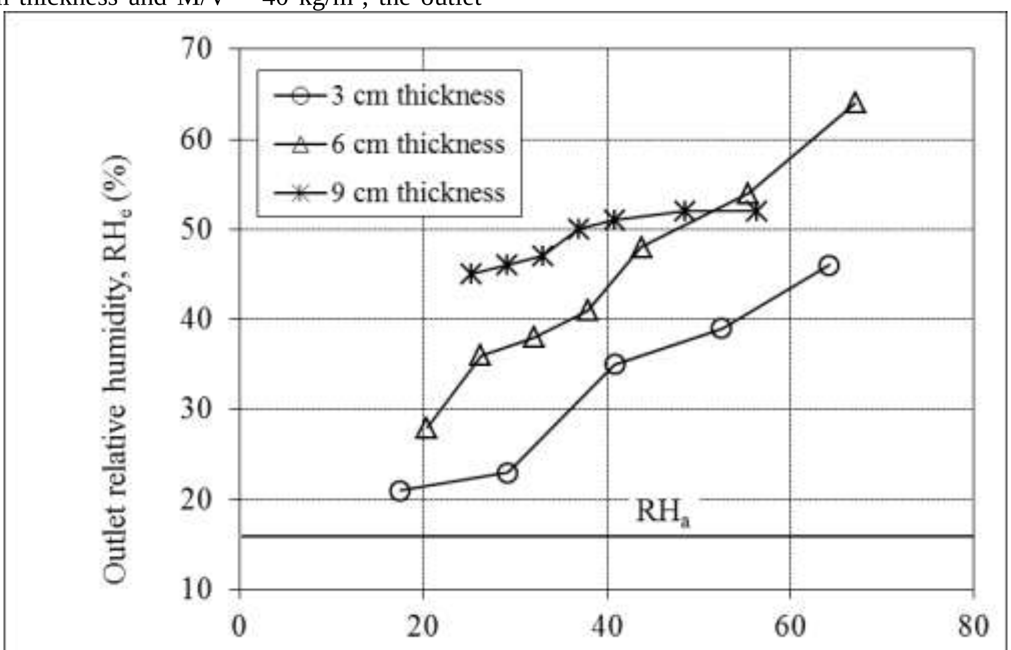

Fig. 4 Mass to volume ratio of palm fiber, M/V (kg/m³)

By calculating the cooler effectiveness, as shown in Fig. 5, it is found that the 6 cm thickness with M/V = 40 kg/m^3 is achieving the maximum value of 67%.

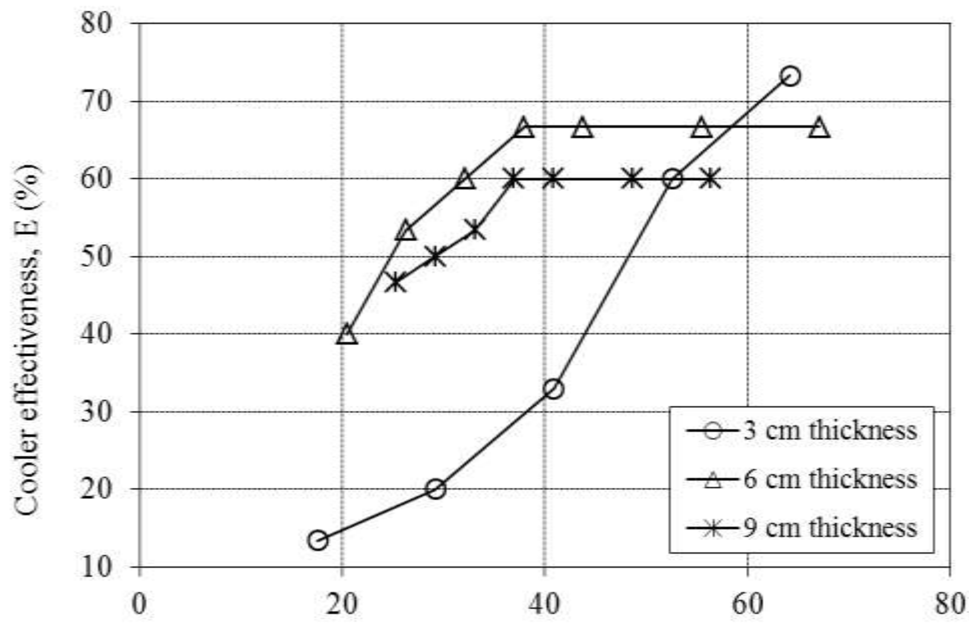

Fig. 5 Mass to volume ratio of palm fiber, M/V (kg/m³)

4.2 Comparison betlween palm fiber and rice straw

A comparison between palm fiber at 6 cm thickness and M/V = 40 kg/m³ and standard commercial rice straw, which is widely used in Aswan, is made.

Fig. 6 shows that the outlet air temperature is approximately the same in both palm fiber and rice straw at different ambient temperatures.

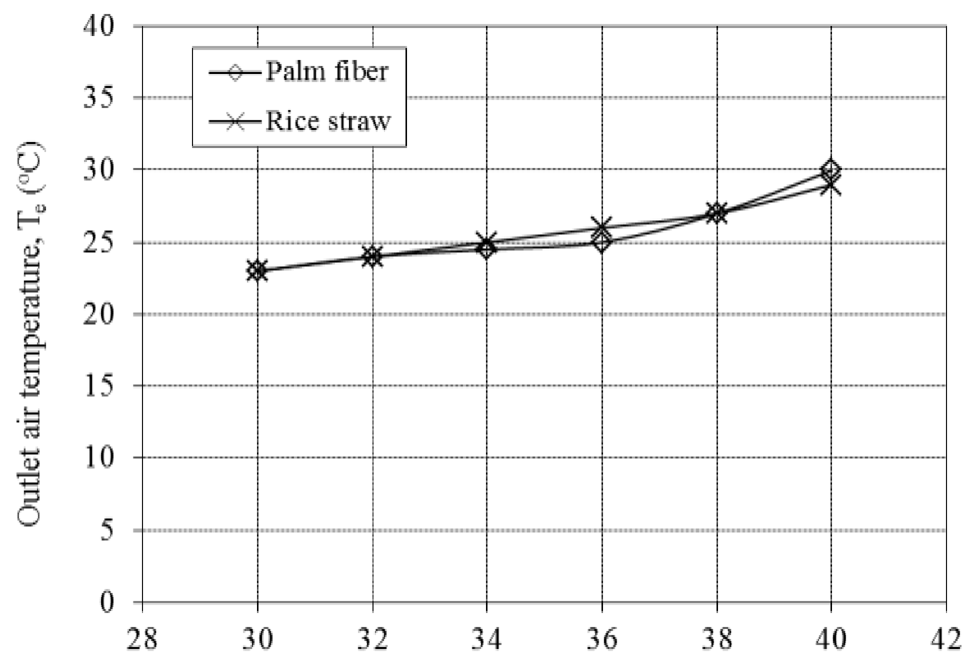

Fig. 6 Ambient temperature, T_a (°C)

As shown in Fig. 7, the outlet relative humidity of palm fiber is lower than that of rice straw with 8 % at 40° ambient temperature, which increases to 19 % at 30°.

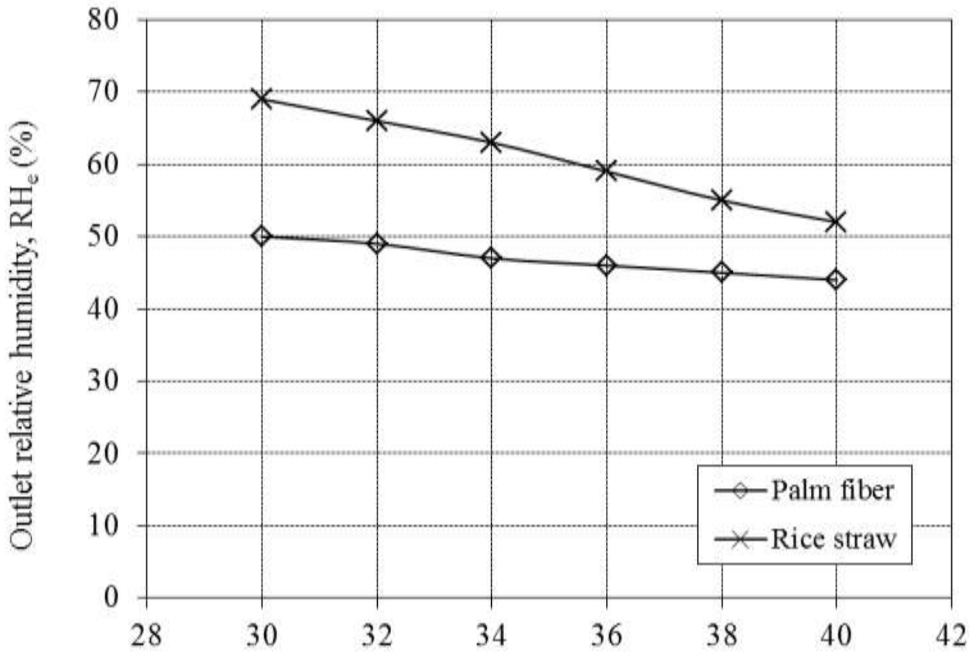

Fig. 7 Ambient temperature, T_a (°C)

Cooler effectiveness's of both fiber palm and rice straw are compared as shown in Fig. 8. The effectiveness of palm fiber is equal to or greater than that of rice straw up to 38^o ambient temperatures. There is 6% increasing of cooler effectiveness when using palm fiber at 36^o ambient temperature. At very high ambient temperature, greater than 38^o, the effectiveness of palm fiber tends to be less than that of rice straw.

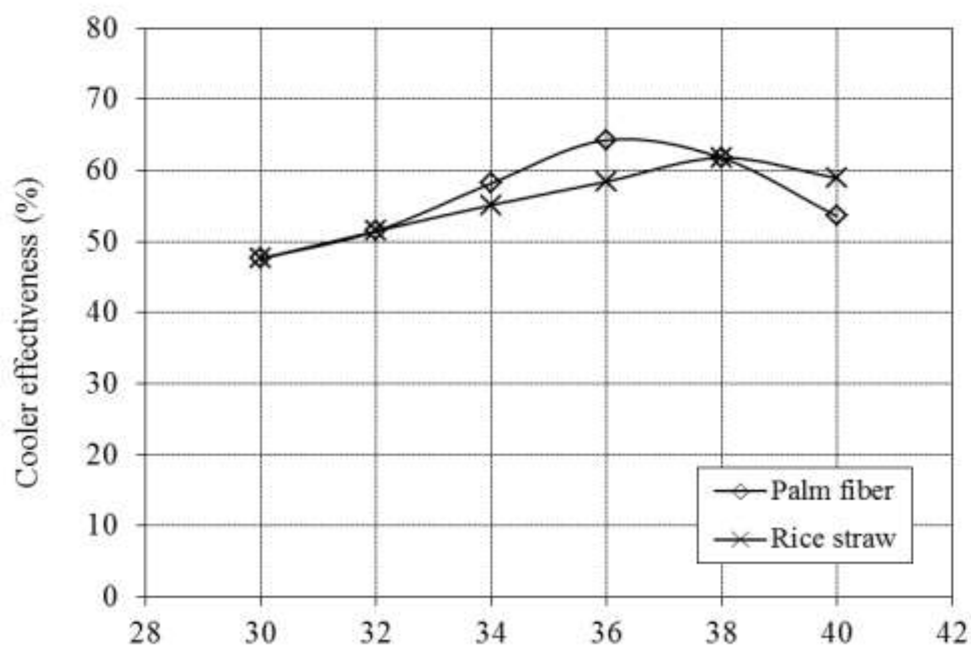

Fig. 8 Ambient temperature, T_a (°C)

5. CONCLUSION

The outlet air temperature and relative humidity are measured with the increase of the weight of palm fiber at three-fixed thickness (3 cm, 6 cm, and 9 cm) to determine the optimum thickness and best volume to mass ratio. The 6 cm thickness with 40 kg/m^3 mass to volume ratio is the optimum selection to achieve economically minimum outlet air temperature and very comfortable outlet relative humidity of 43% with maximum cooler effectiveness of 67%.

The outlet temperature of both optimum selection of palm fiber and that of standard commercial rice straws are the same. Cooler effectiveness of optimum palm fiber is higher than that of rice straw at most working ambient temperatures (32^o – 38^o). The relative humidity is lower than that of rice straw with 13% in average. The local material, palm fibers, with optimum selection (t = 6 cm, M/V= 40 kg/m^3) can be used successfully instead of standard commercial rice straws.

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