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REVIEW PAPER ON INVESTIGATION OF DIRECT EVAPORATIVE COOLER WITH HEMP AND ABACA COOLING PAD MATERIALS

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ABSTRACT

Evaporative cooling is environment friendly and more efficient air cooling method. The efficiency of evaporative cooling systems increases with an increase in temperature and decrease in humidity. Therefore in hot and dry climates, evaporative cooling can save a large amount of energy used for conventional air conditioning systems. Direct evaporative cooler (DEC) uses a wetted pad with large air water contact surface area through which air is passed at uniform rate to make it saturated. However this process is accompanied by an increase in humidity which is sometimes not desirable.

Thus, it is seen that variety of materials that can be used as cooling media in direct evaporative cooler is very large. Hence there is need to analyze the performance of alternative materials in terms of saturation efficiency and cooling capacity. Further, the performance of a cooler using hemp and abaca as cooling media has not been analyzed. Hence the attempt is made to fabricate and analyze the performance of such cooler in the present work.

KEYWORDS— Direct Evaporative cooler, Pad evaporative cooling, saturation efficiency, cooling capacity.

INTRODUCTION

Now a days, great attention is paid to the environment, energy saving and energy efficiency. Energy production often adversely affects the environment and increases greenhouse gas emissions. Despite this, the global energy consumption grows from year to year. That is why the question of the development of new, cleaner and more efficient technologies have been raised acutely in recent years. A large part of the world's energy is consumed by ventilation and air-conditioning. Practically in each modern building ventilation and air-conditioning systems are installed. Even many of the old buildings where possible, are equipped with modern ventilation systems. Many of building facilities, such as hospitals and industrial buildings, have specific requirements for ventilation and air conditioning systems.

One of the most energy-intensive processes in the ventilation and air-conditioning is the process of cooling. Traditional systems based on the compressor cycle consume a lot of energy. Refrigerants contained in compressor circuits are often very harmful to the environment. These factors led to the active development of evaporative coolers. Air coolers based on evaporative cooling of the air consume far less energy compared to traditional compressor systems. They are also more ecological and environmental-friendly systems. However, the efficiency of evaporative air cooling systems is strongly dependent on the state of the air. The most suitable conditions for these systems are the areas with a hot and dry climate. Determining factor in this case is the air wet bulb temperature. This is the theoretical minimum temperature to which air can be cool. Adiabatic cooling is the use of adiabatic process to cool the air passing through a wetted cooling media or a spray of water. The ancient Egyptians hung wet mats on their doors and windows, and wind blowing through the mats cooled the air-the first attempt at air conditioning. This basic idea was refined through the centuries: mechanical fans to provide air movement in the 16th century, cooling towers with fans that blew water cooled air inside factories in the early 19th century, swamp coolers in the 20th century. Modern technology has dramatically increased the efficiency and effectiveness of adiabatic cooling. Adiabatic saturation are good for those

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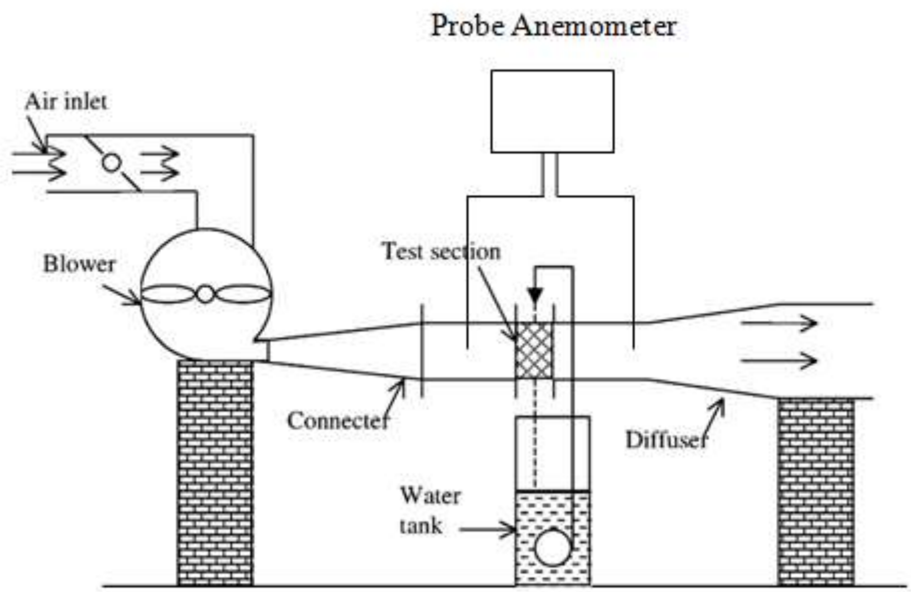
who wants cost cutting budgets because it is designed without a refrigerant, condenser, pressurized pipes to provide comfort cooling, not only the materials are cheap but lesser energy consumption. Another is it uses 100% fresh air so it is healthy because it brings in outside air and exhaust stale air, smoke, odors and germs. It helps maintain natural humidity levels, which benefits both people and furniture and cuts static electricity. Lastly it does not need an air tight structure for maximum efficiency, so building occupants can open doors and windows.

The evaporative cooler works on one of the oldest principles of air conditioning known to Man Cooling of air by the evaporation of water. It is the most common form of household cooling found in arid areas. The popularity of evaporative cooling in such areas is due to its relatively low initial and operational cost compared to refrigerate cooling. Conventional direct evaporative coolers consist of a large water reservoir, a pump that draws water from the reservoir and discharges it through spray nozzles directly into airstream or through cooling pads. The direct evaporative cooler cools the air when the air comes in contact with water in the wetted media (cooling pads).During evaporation of water in air stream, the required heat is taken from air itself. By using Hemp and Abaca pad material the test will be taken for analysis purpose.

Experimental setup will be,



LITERATURE REVIEW:

Now-a-days some buildings use air conditioning systems which are based on vapour compression refrigeration system. These systems consume substantial power and may be harmful to environment. Therefore it is very much needed to have low energy consuming devices such as evaporative cooling systems for providing thermal comfort in buildings. Many researchers have carried out research in order to improve performance of such systems.

Abdullah *et al*. [1] has found maximum efficiency at velocity 1.8 m/s for thickness 150 mm in pad 5090, on other hand the maximum pressure drop occur at thickness 75 mm for pad 7090 and velocity 1.8 m/s. Furthermore the minimum evaporated water is about 0.06 lit/min for thickness 75 mm at 1.8 m/s air speed in pad 7090. They concluded that when the air speed decreases and pad thickness increases, the optimum point may occur.

R. K. Kulkarni *et al* [2] observed that the saturation efficiency decreases with increase in mass flow rate of air. They have also seen that material with higher wetted surface area gives higher saturation efficiency and they obtain result, the Aspen material gives highest efficiency of 87.5 % while cellulose material gives lowest efficiency of 77.5 %. J.K. Jain, D.A.

Hindoliya [3] concluded that performance of palash fibers to be better than that of other materials. They found effectiveness of palash fiber was 13.2% and 26.31% more than that of aspen and khus fibers respectively. The effectiveness of pad with coconut fibers was found to be 8.15% more than that of khus and comparatively with that of aspen pad. Palash fiber is well known material and has good water retain capability; it may be a better alternative to aspen fibers. Coconut fibers are also easily available and found to be better than aspen fibers. And they also observed that the Palash fiber offers about half the pressure drop compared to that of aspen. Therefore, these fibers may also be used as wetted media in evaporative cooling devices for higher effectiveness.

Faleh Al-Sulaiman [4] has designed special setup to evaluate the performance of natural fibers. He found the results that the average cooling efficiency is highest for jute at 62.1%, compared to 55.1% for luffa fibers, 49.9% for the reference commercial pad and 38.9% for date palm fiber. And summarized the material degradation, the Jute has the least salt deposition with 4.8% (g of salt/g of dry fiber). Palm fiber and luffa have 27.3% and 37.2% respectively and commercial fiber has the highest amount of salt deposition (82%). And also found the mold formation highest for the jute fibers. Almost all the surface was affected (96.6%).Luffa has the lowest mold formation (8.6%). Palm and commercial fibers have 52.6% and 76%, respectively.

Akintunji *et al.* [5] has analyzed the performance of coconut coir pad as a media in direct evaporative coolers. The primary air mass flow rate considered varies between 0.16 kg/s to 0.54 kg/s and the performance analysis of the coconut coir pad is based on the saturation efficiency, leaving air temperature, relative humidity, cooling capacity and water consumption. They found the results of the analysis of the coconut coir based on the air flow rates considered reveal that the saturation efficiency decreases from 64.7% to 55.9%, the leaving air temperature increases from 25.2^{0}C to 27.1^{0}C, relative humidity decreases from 46.4% to 38.2%, the cooling capacity increases from 8230 kJ/h to 24055 kJ/h and the water consumption increases from 3.57 kg/h to 9.72 kg/h. And from the results they concluded that the coconut coir pad performed better at lower air mass flow rates where lower leaving air temperature and relatively higher relative humidity are obtained.

Banyat *et al.* [6] has studied the efficiency of two different type of cooling pads made of a curtain fabric and a raw cotton fabric. They analyzed the effect at different speed of blower at 725, 1015, 1450 rpm and investigated the water flow rate 26 lit/min. And also found the saturation efficiency range between 46.3 to 61.3 % for curtain fabric and 29.7 to 39.2 % for raw cotton fabric. An average inlet and outlet temperature difference were 2.9 and 1.7 for a curtain fabric and a raw fabric, respectively.

Dutta *et al.* [7] conducted experiment on 8.5 ton indirect evaporatingcooling system and found that it is an attractive option in India and Australia with potential energy saving of 75% over AC in climatic zone where WBT is less than 25^{o}C.

Abdul Rehman *et al.* [8] experimentally investigated performance of DEC in hot and humid regions of Malaysia. He found output air temperature, 27.5 to 29.4 while cooling capacity between 1.38 kW to 5.53 kW.

R.Bonkhanouf *et al.* [9] presented a computer model and experimental result for porous ceramic materials with outride DBT 45 and proved that, air can be cooled below its WBT with maximum cooling capacity of 280W and overall wet bulb effectiveness is found more than unity. He strongly recommended potential of DEC as alternative to conventional AC for dry and hot regions.

Maqsood *et al.* [10] investigated ability of EC to provide indoor comfort condition irrespective of outdoor condition. He found that indoor DBT is dropped to 8 to 16 in low RH (10%-30%) and 4 to 5 in higher RH. He proposed on off control system to maintain inside RH within comfort limit.

Buffington *et al.* [11] compared the evaporative cooling pads made of four different materials because of cooling efficiency. In the study, the velocity of the air passing through the pad was kept stable at 0.75 ms-1. At the end of the study, they stated that the maximum cooling efficiency was attained at a cement compounded sugar beet pulp pad, which was followed by a cellulose based pad, while the lowest efficiency was attained at apad made of rubberized pig bristle.

Koca *et al.* [12] assessed the functionality of three different cellulose pads in an experiment set in accordance with the standards of AMCA (Air Movement and Control Association) and ASHARE (American Society of Heating, Refrigerating and Air-Conditioning Engineers). The first pad examined at the study had a thickness of 10 cm with45 to 45° chamfer angle, while the second had a 15 cm thickness with 45 to 45° chamfer angle, and the last pad had a 15 cm thickness with 30 to 30° chamfer angle. They found that the cooling efficiency of the pad with 10cm thickness and 45 to 45° chamfer angle, varied from 73to 90% at 1.5 to 2.5 ms-1 air velocity.

Dağtekin *et al.* [13] carried a study in Cukurova Region (Adana, S.Turkey), to determine the most suitable pad material for evaporative cooling system, by comparing pads made of poplar sawdust, nutshell and cellulose. As a result of the study, the authors determined that cellulose based pad was the most suitable material for the mentioned region; however, they also affirmed the use of nutshell pads due to their inexpensive cost and long durability.
Hacisevki H *et al.* [14] based on the Nicosia- Cyprus region 1996 and 1997 climate data, theoretically studied the availability of evaporative cooling systems in closed environments in the region. As a result of the study, they determined that evaporative cooling systems could be used especially between May and June months in Nicosia-Cuprus region.

Cruz *et al.* [15] evaluated three different pad materials efficiencies at different temperatures and air velocity in a study conducted in Evora - Portuguese. In the study conducted at four different temperature ranges with an air velocity of 1.6,3.2, 4.8 and 5.6 ms-1 respectively, the highest cooling efficiency (80% and more), was achieved at 3.2 ms-1 air velocity at temperatures of 32 to 34°C.

Yild *et al*. [16] examined some performance characteristics of the cellulose-based evaporative cooling pad at different air velocities in Mediterranean climate conditions. In their study, 0.5, 1.0 and 2.0 ms-1 value were chosen for the velocity of the air passing through the pad, while the pad wetting water flow rate (4 Lmin-1m-2) was kept stable. As a result of the study covering the period from June to September, it was determined that the cooling efficiency at the selected air velocity was 77 to 84%, provided temperature decrease was between 6.7 and 5.6°C and the amount of vaporized water varied between 0.078 and 0.210 L min-1 m-2.

Dağtekin *et al.* [17] examined some performance characteristics of an evaporative pad cooling system in a broiler poultry house at Mediterranean climate conditions. As a result of the study that was completed in July to August, it was determined that the cooling efficiency of the system varied between 70 and 80% and nearly 10°C temperature decreases were achieved at the outer environment air extracted into the poultry house by passing through the pads.

R.K.Rajput *et al.* [18] performed a theoretical study of performance of evaporative cooler with different cooling pad shapes and materials are made. Rectangular, cylindrical and hexagonal shaped pads of rigid cellulose, corrugated paper, high density polythene packing and aspen fiber material are considered. Geometrical parameters of pad shape like area, volume are calculated for air velocities between 0.75 to 2.25 m/s. Based on weather data of Bhopal, India, inlet condition of 39.9 ^{0}C dry bulb temperature and relative humidity of 32.8 % is selected for the analysis. Saturation efficiency, dry bulb temperature of outlet air and cooling capacity are estimated. Saturation efficiency decreases with increase in mass flow rate of air having highest value of 91 % for hexagonal shaped pad with aspen material. It is followed by cylindrical (90%) and rectangular (89 %) pads. The cooling capacity increases with air mass flow rate having minimum value of 35826 kJ/h for rectangular pad with cellulose material for air mass flow rate of 0.3 kg/s.

CONCLUSION
Following conclusion can be drawn from the literature review performed above

- Direct Evaporating cooling can provide higher level of thermal comfort in humid as well as dry regions.
- Researchers from all over world are trying to search or develop new efficient and sustainable pad materials which are very much required for further enhancing cooling potential of evaporative cooling devices.
- From the research studies mentioned above, it become clear that there are no studies about hemp and abaca as wetted pad materials.
- Evaporating cooling has large potential to provide indoor comfort condition at reduced operation cost in region where WBT is less than 24^{O}C.
- The velocity of the air passing through the pad is the most important feature that needs to be chosen carefully at the design and operation of pad evaporative cooling systems.

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