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SOLAR OPERATED WATER CUM AIR COOLER

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Abstract—India is a tropical country which experiences a very high temperature during summer and becomes highly uncomfortable for the people. For cooling purpose people use refrigerator and air coolers which generates a high electricity bill, which leads to the investigation of water cum air cooler using the principal of evaporative cooling and thermosyphon, using solar energy as the source of power. This paper shows the research work in solar operated water cum air cooler using clay pots, which can overcome the problem of high electricity bill, wastage of water used for cooling purpose and the cause of global warming due to the refrigerants used in the VCR system.

Index Terms—Water cooler, Claypots, thermosyphon, solar cooler, air cooler, evaporative cooling,clay properties.

1 INTRODUCTION

Refrigeration is defined as the process of removing heat from a body or enclosed space so that its temperature is first lowered and then maintained at a level below the temperature of surroundings. In such a case, the body or enclosed space is said to be refrigerated system.

Refrigeration in its natural from dates to medieval times when food preservation was achieved by storing it in cave which were colder than the prevalent atmosphere outside. Also, cooling of products for preservation was achieved by immensingthem either in a steam of cold water or in cold shallow well. These methods could produce the temperature upto 10 to 15 degree Celsius. Cooling of water in earthen porous pots is well known to mankind.
Mechanical domestic refrigerators and air conditioners became a reality in the year 1920 and the progress in the field of refrigeration since then has been phenomenal. At present refrigeration and air conditioners have became household terms and leads to high electricity consumption. It is found that around 30% of electricity is used for the application of these.

2EVAPORATIVE COOLING

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 times. Evaporative cooling is based on the thermodynamic process of evaporating water to the surrounding air, which involves exchange sensible heat and latent heat between air and exposed water surface at constant enthalpy. Spontaneous escape of high energy molecule from liquid surface in vapour state is termed as evaporation and by the same principle for cooling it termed as evaporative cooling. It is also known as adiabatic cooling and isenthalpic cooling.

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2.1 Evaporative cooling in porous media

There is mass (water) transfer through a porous media. Some of its application are listed below:

One application of evaporative cooling through media is a traditional system of cooling water for drinking. The water inside a ceramic porous container is cooled in the following way: the water inside the container goes through the porous wall and evaporates in its surface, taking the necessary energy from the water.

3 CERAMIC/CLAY POTS

Ceramic in an inorganic, non-metallic solid prepared by the action of heat and subsequent cooling. They withstand chemical erosion that occurs in other materials subjected to acidic or caustic environment. Ceramic pots are made of normal mud used for making water pots which is present in abundant, cheaply available everywhere and easy to process. It is heated at 70 degree Celsius for five hours. A material's strength is dependent on its microstructure. The engineering process to which a material is subjected can alter this microstructure. Theoretically, a material could be made infinitely strong if its grain is made infinitely small.

3.1 proprties of clay/ceramic material

Clay pipe is made of chemically combined silica, alumina and water.In its natural state, it is rarely pure and usually contains impurities such as sand, limestone, pebbles, iron oxide and traces of other elements it has accumulated over the long period of time it has taken to become clay. These impurities in any combination provide the clay with a unique set of properties that make different types of clay useful for different purposes. Pure clay with little or no impurities lacks some of the properties that a potter need.

1) Shrinkage --- The reduction of the clay mass that occurs when water in the clay evaporates

during drying and firing.

2) Plasticity --- The property of the clay that allows it to change shape without tearing or breaking.
3) Moisture --- All clay has moisture, as the moisture evaporates the clay gets harder to shape.

4 THERMOSYPHON

Thermosiphon is a circulating fluid system whose motion is caused by density differences in a body force field which results from heat transfer. Mechanical inputs have so far been excluded from all thermosyphon studies. Davies and Morris Scientist have suggested that thermosyphon can be categorized according to the nature of boundaries.

Furthermore, thermosyphon flows are intrinsically driven by thermal buoyancy forces, either locally or in an overall sense. A simple loop flow may well be the result of local buoyancy forces alone, but a multi branched flow circuit can easily incorporate sections in which the flow direction is contrary to the local buoyancy force resulting from pressures created by the overall system buoyancy forces.

4.1open thermosyphon

The open thermosyphon provides a basic starting point for considering thermosyphon systems. Specifically, it was found that for large heat fluxes, the buoyancy forces are sufficiently intense near the wall so that a boundary layer regime is obtained. For weaker heat fluxes, the buoyancy forces are less, and the effect of shear is relatively enhanced causing the boundary layer to fill the entire tube.

5 WORKING

When the cooler starts (solar energy is used) the normal water from the tank is transferred to the matkas kept in rows one above the other through the pipe. A fan of high rpm will be running behind the matkas. The matkas has small pores through which water sweeps out the surface, on reaching there it evaporates. The heat required for evaporation is taken away from the outer surface which makes the outer surface cooler and the water inside the matka becomes cold this cold water is connected to pipe which connects the outlet of the tank, and we know that temperature is directly proportional to kinetic energy, since the kinetic energy becomes less after evaporation and hence we get a cooler air and water.

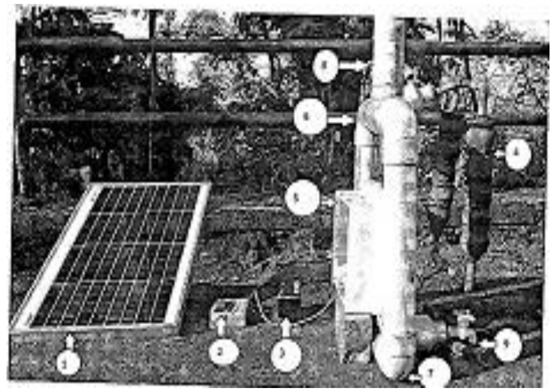

Fig.1 Experimental setup

In the proposed evaporative cooling water filled in porous clay pots goes throughthe porous wall and wets the surface. This water evaporates because of air sweeping across the container surface. The surface and thus air get cooled. The noticeable fact is that the cooled air does not carry water droplets with it. A limited amount of water just enough to lower its temperature by few degrees is added to the air. The temperature of the air is further reduced sensibly due to its contact with the cooled pots surface. This cooling technique should be especially relevant at present when depleting fossil fuel reserves and environmental problems caused by the rapid use of such fuels are ofmounting global concern. For better human comfort, living or work environment is vital in tropical climates.

Total Heat absorbed by the water

$Q = Le*(m1-m2)$ KJ

Heat absorbed from water in pot

$Q1 = m1*Cp*(T1-T2)$

Heat absorbed from air

$Q2 = (Q-Q1)$ KJ

Heat absorbed from air

$Q2 = (Q-Q1)$ KJ

Temperature drop of air

$Q2 = ma' * Cp * dt$

ma' = air flow rate

heat transfer rate from air $(Q2') = Q2/t$ KJ/S

5.1 expected outcomes

As the time increases temperature decreases and amount of water evaporated increase exponentially. So, we can assume that temperature of air and amount of water present in the pot is inversely proportional to time. By using clay pipes for evaporating cooling could be help for decreasing the CO2 emission and ozone-depleting Chloro Fluro Carbons (CFCs).

Fan Vel.	DBT	DBT	%RH
1	33.5	25.2	52
2.3	32	24.7	57
4.7	31.1	24	60
7	29.2	23	61

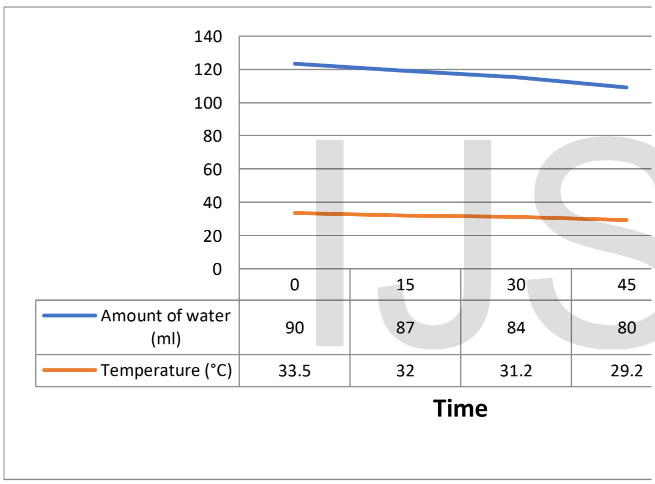

Fig.1.Graph

6 MERITS OF SOLAR OPERATED WATER CUM AIR COOLER

One of the biggest advantage of this system is the higher thermal power generated per square meter of area. People don' t need to buy two different system and can save a lot of money by lesser electrical consumption. It can also help in the reduction of greenhouse gases.

Works better on hotter days and hence reduces demand charges. Saves water which was earlier wasted in water coolers.It can lead to higher energy efficiency ratio of up to 36% as compared to 12% for compression refrigeration system. Helps in maintaining the pH level of water due the use of clay pots.

7 CONCLUSION

After investigating the performance of Solar operated water cum air cooler, the following key conclusionshave been derived:

1) The decrease in DBT reduces with increase in fan speed i.e. the leaving airtemperature increases with increase fan speed. The decrease in conventionalevaporative coolers is around 5-8° C whereas a temperature reduction of 14° C was achieved in solar operated water cum air cooler.

2) The difference in RH of leaving air and entering air decreases with increase in fanspeed, the variation being high at lower speed and vice versa. The rise in RH obtainedis around 8-10 %

3) The effectiveness of this has been observed to increase with increase in drynessof outside air.

4) Particularly staggered position demonstrates high air temperature drop compared toalign one. For staggered position air temperature drop was 11° C (5 cm pitch), 9° C(10cm pitch) and 7° C (15cm pitch) at 1m/s air velocity. Much greater pressure dropwas accrued in the 5 cm pitch compared to 10 cm and 15 cm pitch distance. At lowerair velocity of 1 m/s with 5 cm pitch distance, the relative humidity is 9% and 7% forstaggered and aligned condition.

5) The heat and mass transfer coefficient of experimental value are compared withColburn heat transfer group and it is within the limit of 20%.

6) The maximum evaporative cooling effectiveness is 45% and 53% in aligned and staggered position at 1m/s air velocity.

REFERENCES

[1] Dr. Banoth Mohan, Satish Konatham, "Advanced Hollow Pipes Made of Ceramic AirCooler", International Journal & Magazine of Engineering, Technology, Managementand Research, Vol. 03, 2016, P.P. 72-77.

[2] Indra Prakash Yadav, Himanshu Srivastava, Bansh Raj Yadav, Arun Kumar Yadav,Rohit Jain, "Clay Mechanism based Air Cooler", International Journal of Research inEngineering and Technology, Vol. 7, 2018, P.P. 28-31.

[3] Katarina Gustafsson Hanna Simson, "An experimental study on an evaporative coolerfor hot rural areas", Bachelor of Science Thesis EGI, 2016.

[4] Maneesh Dubey and SPS Rajput, "Development and Performance Evaluation of aSemi Indirect Evaporative Cooler", International Refrigeration and Air ConditioningConference, 2008, Paper 978.

[5] R. Ramkumar1 and A. Ragupathy, "Experimental Investigation of IndirectEvaporative Cooler using Clay Pipe", Journal of Thermal Engineering, Vol. 3, 2017,P.P. 1163-1180.

[6] Lu, L., Wang, X., Wang, S., & Liu, X. (2017). Optimal Structure Design of a Thermosyphon Solar Water Heating System with Thermal and Dynamic Models. Heat Transfer Engineering, 1–12. doi:10.1080/01457632.2017.1379347

[7] Japikse, D. (1973). Advances in Thermosyphon Technology. Advances in Heat Transfer Volume 9, 1–111.

[8] Swapnalee, B. T., & Vijayan, P. K. (2011). A generalized flow equation for single phase natural circulation loops obeying multiple friction laws. International Journal of Heat and Mass Transfer'

[9] Experimental investigation of steady and transient operations of a single-phase closed-loop vertical thermosyphon panelIuriiLokhmanetsBantwal R.(Rabi)Baliga.