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"Utilization of Greenhouse Effect to Enhance Evaporative Cooling"

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ABSTRACT

Air conditioner is commonly used in assuring thermal comfort for the humans, but it is very expensive since it has high initial cost and it consumes large amount of electricity. Also, refrigerant used in air conditioners are harmful for environment as they are responsible for global warming and ozone layer depletion. This paper aims to review the possibility of designing and fabricating an air conditioner using evaporative cooling. This method is opted to achieve an economical design which is affordable, eco-friendly and consumes less energy, since evaporation is done by earthen pots and there is no need for compressor. Though this method consumes a considerable amount of time to get the required result but it is as effective as any traditional air conditioner. In this report, we have continued our previous work on evaporative cooling and prepared a model on the concept of the previous study on evaporative cooling. In this stage we have also employed the greenhouse-effect to provide a suitable environment for the evaporation process.

Keywords: Greenhouse Effect,Evaporative Cooling

Introduction

Evaporative cooling

Evaporative cooling has existed as long as the Earth has had water on its surface, whether as oceans, lakes, ponds or streams. It is no accident that prehistoric animals and primitive humans sought out water sources, especially in hot environments, because they needed it to survive. But proximity to water provided a powerful benefit beyond hydration – natural cooling. Ancient Egyptian frescoes dating to about 2500 BC provide the earliest evidence that people developed systems to leverage the natural power of evaporative cooling. In these plaster paintings on temple walls, slaves are shown fanning urns filled with water to cool Egyptian royalty. Common Egyptians as well as Romans hung wet mats over doors and windows to help cool their living spaces. Wealthy Romans maintained a cooler air temperature in their homes cooler with water circulated from the aqueducts through pipes in the walls. Medieval Persia (now Iran) is credited with building the first evaporative cooling towers that trapped wind and funneled it past water at the base and into a building. No other than Leonardo da Vinci, the great Renaissance inventor, thinker and artist, sketched an early mechanical air cooler as part of his exploration of energy and water. His sketches show a water wheel with flaps or paddles that directed air as it passed over the wheel. Fast-forward a few centuries. Settlers in the American Southwest hung wet sheets on porches to create a cooler spot to sleep.

Electricity accelerates evaporative cooling advancement

The biggest change, though accompanied widespread use of electricity in the early 1900s. In the Southwest, notably Arizona and California, air coolers – both direct and indirect – used water to create cooler air. Early designs forced air through wet cloth attached to a wooden frame. Adding sump pumps or recirculating pumps kept water moving and became the foundation for machines known by different names, from wet boxes to drip coolers and desert coolers to swamp coolers.In them, a fan pulls air through thick, wet pads but mineral deposits in the water clog these membranes, which need regular cleaning and maintenance. This traditional approach to evaporative cooling is also demands significant amounts of electricity and water. Uncovering the physics behind Evaporative Cooling

LITERATURE REVIEW

2.1 Design and fabrication of solar based evaporative cooling air conditioner

This paper describes design and fabrication of air conditioning system that uses solar evaporation to obtain cooling. The basic idea was to design a system that is affordable, consumes less energy and gives the same effect as that of the conventional air conditioner. This system provides satisfactory results. The only disadvantage observed; is long time required to get the desired cooling effect.

2.2 Thermal Analysis of Clay Pot in Pot Refrigerator

Cooling through evaporation is an ancient effective method of lowering temperature. The simple clay pot refrigerator is ideally suited for preserving vegetarian food and water in hot and dry climates. The refrigeration takes place by evaporation through the porous pot material. The present work includes experimental analysis of a clay pot in pot by varying height of water in the inner pot, by varying water level in the annulus of two pots and by subjecting the pot in pot refrigerator for free and forced convection. Results obtained from experimental analysis shows that Temperature T1 is highest when inner pot is filled with 5.5litres of water and lowest when it is filled with 1.5 litres of water. Temperature T1 decreases by increasing water level in the annulus of two pots and rate of cooling is lowest when pot in pot refrigerator is subjected to free convection and highest when it is subjected to forced convection.

2.3 A review of evaporative cooling technologies

Air-conditioning plays an essential role in ensuring occupants thermal comfort. However, building's electricity bills have become unaffordable. Yet the commercially dominant cooling systems are intensively power-consuming ones, i.e. vapor compression systems. This paper aims to review the recent developments concerning evaporative cooling technologies that could potentially provide sufficient cooling comfort, reduce environmental impact and lower energy consumption in buildings. An extensive literature review has been conducted and mapped out the state-of-the-art evaporative cooling systems. The review covers direct evaporative cooling, indirect evaporative cooling and combined direct-indirect cooling systems. The indirect evaporative coolers include both wet-bulb

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temperature evaporative coolers and dew point evaporative coolers have been of particular interest because of high thermal performance. The dew point evaporative coolers have shown great potential of development and research opportunity for their improved efficiency and low energy use.

Problem Identification

The current methodology used for air-conditioning purposes works on the VCR cycle, the working of which has been explained in the previous chapter. Now, for the VCR cycle to operate some external supply of energy has to be provided so that the cycle follows the **Second Law of Thermodynamics.** This external energy is supplied via a compressor that compresses the refrigerant in vapor form and thus causing a rise in the pressure and temperature of the refrigerant. This excess temperature then causes the removal of heat from the system. This excess energy is supplied as electrical energy to the compressor, which converts this energy into mechanical energy thereby compressing the vapor. This input of energy adds to the amount of energy that is being provided to the cycle. Now, efficiency being the ratio of Output to input, decreases.

Following are some of the problems identified during the operation of a VCR cycle:

Large Input Requirement: -

The electrical power required to maintain the compressor in constant working condition is quite large (as compared to the Refrigeration effect obtained). So, for a person to enjoy the luxury of air-conditioner, it would require quite a fortune. Air-conditioners nowadays are used in almost every sector such as agriculture, defense, Professional and corporate world etc. so, a big part of the produced energy is being invested for air conditioning. The concept of Evaporative **Cooling (**explained in the next chapter**)** discards the use of compressors for cooling purposes.

Requirement of an isolated volume: -

For the proper and efficient working of VCR cycle, the volume to be air-conditioned must be kept as much isolated as possible, so that the evaporation occurring inside the volume remains uniform. The concept of Evaporative cooling does not have this restriction and can function without an isolated volume.

Refrigerants used and their Effects: -

In 1987, researchers concluded that the Chemical compounds in our most widely used refrigerants – known as chlorofluorocarbons (CFCs) – are a major source of destruction to the lower atmosphere, resulting in sweeping regulation of CFCs within the market.

Research showed that once CFCs reach the stratosphere, the sun’s ultraviolet rays break down the compound, thus releasing chlorine. This resulting chlorine damages the atmosphere in a repetitive process, depleting the ozone layer until the refrigerant is broken down which, in the case of chlorine, takes 2 entire years.

This means that the common refrigerants historically used in both residential and commercial HVAC alike put our safety at risk – depleting the ozone that is essential for protecting every living organism on Earth from harmful ultraviolet (UV) rays from the sun.

Working Principle

Evaporative cooling is a process that uses the effect of evaporation as a natural heat sink. Sensible heat from the air is absorbed to be used as latent heat necessary to evaporate water. The amount of sensible heat absorbed depends on the amount of water that can be evaporated.

Evaporative cooling can be direct or indirect; passive or hybrid. In direct evaporative cooling, the water content of the cooled air increases because air is in contact with the evaporated water. In indirect evaporative cooling, evaporation occurs inside a heat exchanger and the water content of the cooled air remains unchanged. Since high evaporation rates might increase relative humidity and create discomfort, direct evaporative cooling can be applied only in places where relative humidity is very low.

Where evaporation occurs naturally it is called passive evaporation. A space can be cooled by passive evaporation where there are surfaces of still or flowing water, such as basins or fountains. Where evaporation has to be controlled by means of some mechanical device, the system is called a hybrid evaporative system.

Greenhouse effect- It refers to the absorption of heat radiated in an enclosed area by GREENHOUSE GASES. The greenhouse gases have a tendency to trap in the heat from any source such as direct sunlight.

Now this heat can be used as a property that is favorable for evaporative cooling.

Working of the model

As the water in the evaporative volume cools down, the water in the earthen pots transfers this cooling effect to the copper coils that are dipped into the water. The flowing medium (i.e. water) in the copper tube gets cooled down due to this transfer of the cooling effect. Now, this cooled water travels in the cooling circuit due to the pressure generated by the pump and goes into the into the second pot, where the same process is repeated. Two pots are used so that there is continuous cooling of the flowing fluid and the heating of the fluid due to environment is cancelled out. The water, after passing twice through the pots, enters the inlet of the heat exchanger where it flows through its coils (the material of these coils is again copper). The heat exchanger also consists of aluminium fins that increase the surface area for the air to convect.

Figure: Heat exchanger

The heat exchanger is now placed in an enclosed volume that consists of only one inlet and only one outlet. In the indoor unit, a fan is fixed from the outside near the heat exchanger whereas the heat exchanger is inside the cooler. Now, when the cooled water flows through the H.E, the fan sucks air from the room and forces it towards the H.E and due to cooling action through the pipes and the fins, the air now loses its temperature. also, if the temperature of the flowing liquid reaches the dew-point temperature of the air in the room, it will result in the condensation of water vapor and hence dehumidification will be achieved.

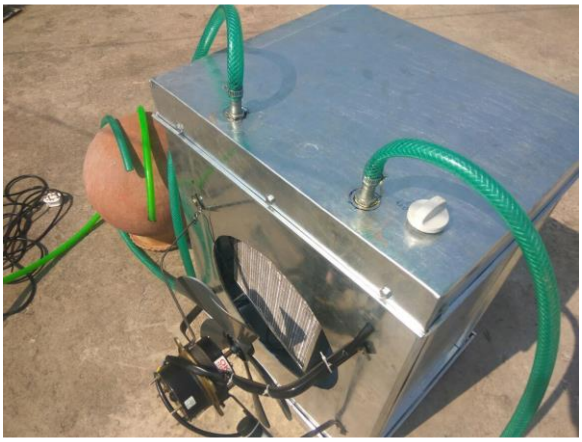

Figure: Indoor unit arrangement

Figure: Overall arrangement of the model

Conclusions

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Based on the arrangement explained in the previous sections, we have collected data from both

S.No	Time	E1 (Temperature of water in the first pot) (in degree Celsius)	E2 (Temperature of water in the second pot) (in degree Celsius)

outdoor unit and the indoor unit and compared them based on the time interval in which they were recorded. This helped us to get a brief view on how efficient our transmission system was. The table(table 4.4) containing the relevant data is shown in the next page.

Table: Temperature in the two pots respective to the time

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1	1:00 PM	28.37	28.31
2	1:25 PM	27.12	27.57
3	1:50 PM	25.85	26.12
4	2:15 PM	23.96	24.35
5	2:40 PM	22.69	23.19
6	3:05 PM	21.81	22.31
7	3:30 PM	21.12	21.8
8	4:00 PM	20.43	20.98
9	4:30 PM	19.8	20.11

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Table: Temperature in the reservoir respective to the time

S.No	Time	Temperature of the reservoir (in degree Celsius)
1	1:00 PM	28.37
2	1:25 PM	27.37
3	1:50 PM	26.81
4	2:15 PM	26.16
5	2:40 PM	25.34
6	3:05 PM	24.68
7	3:30 PM	23.82
8	4:00 PM	22.96
9	4:30 PM	21.87

S.No	Time	Pump	Exhaust Fan	Room Temperature (In degree Celsius)	Relative Humidity (In % of mass)
1	1:00 PM	OFF	OFF	31.67	42.67%
2	1:25 PM	OFF	OFF	31.67	42.67%
3	1:50 PM	OFF	OFF	31.67	42.67%
4	2:15 PM	OFF	OFF	31.67	42.67%
5	2:40 PM	OFF	OFF	31.67	42.67%
6	3:05 PM	ON	ON	31.67	42.67%
7	3:30 PM	ON	ON	31.00	42.67%
8	4:00 PM	ON	ON	30.37	41.39%
9	4:30 PM	ON	ON	29.24	40.56%
10	5:05 PM	ON	ON	28.51	38.32%
11	5:35PM	ON	ON	27.36	37.12%
12	6:00 PM	ON	ON	26.12	35.83%
13	6:30 PM	ON	ON	24.67	34.36%
14	7:00 PM	ON	ON	23.28	32.31%
15	7:30 PM	ON	ON	21.96	30.65%

Table: Temperature in the room respective to the time

Based on the obtained data, it is quite clear that the cooling obtained by the arrangement is not rapid and takes time to produce the initial cooling effect.

The decrease in humidity also takes place after a considerable amount of time, so in conclusion our group agreed on the following points

1. The system, although being able to produce cooling and dehumidification requires modifications in the design to obtain a more efficient arrangement.

2. The number of evaporative volumes used can be increased in order to get better results for both cooling and dehumidification.

3. The indoor unit needs to be converted into a more compact and insulated volume, so that cooling losses can be avoided.

4. A higher thickness of acrylic sheet results in better rate of evaporation and hence more cooling is obtained as compared to thinner sheets.

5. Power required to run the whole system is just a high pressure pump and the output is both cooling and dehumidification, so further research on the topic might result in a better and efficient system than the VCR cycles traditionally used.

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