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Design and Fabrication of Air Conditioner with 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.
Keywords : Evaporative Cooling, Design and Fabrication, Science of psychometrics

I. 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. The following timeline traces the history of some key scientific discoveries and developments in the science of psychometrics:

Table 1

16th Century	First Hygrometer	Leonardo da Vinci at the beginning of the 16th century was credited with inventing the first hygrometer that used a ball of wool to provide this indication of humidity level.
	First Mechanical Air Cooler	Da Vinci was likely the first to use a mechanical air cooler. This air cooler consisted of a hollow water wheel with an air passage constructed to guide the air from the water wheel to his patron's wife's boudoir. The air was cooled by the splashing and evaporation of water during operation of the water wheel. Motive power was provided to move the air by the water turning a partially submerged wheel. Namely, as sections of the wheel would be submerged into the stream water level moved from the outer edge of wheel toward the center compressing the air in this chamber and forcing it to move through the passages to the boudoir.
17th Century	Pascal's Rule for Liquid Pressure	Blaise Pascal presented the rule: pressure exerted anywhere on a confined liquid is transmitted unchanged to every portion of the interior and to all the walls of the containing vessel; and is always exerted at right angles to the walls.
	Boyle's Law	Robert Boyle developed one of the four principles that govern performance of evaporative cooling: if the temperature of dry gas is constant, then its volume varies inversely with the pressure exerted on it.
18th Century	Fluid Dynamics	Bernoulli, Euler, Pitot, Chezy, and others applied the techniques of mathematical physics to develop the science of fluid mechanics. John Dalton established the nature of evaporation, and its importance to the global cycle.

19th century	Flow through Porous Media	Darcy (1856) established an understanding and quantitative characterization of flow through porous media.
20th century	Psychrometric Charts	Willis Carrier's development of a psychrometric chart similar to ones in use today along with the development of a formula that linked the transformation of sensible heat into latent heat during the adiabatic (no external heat input or output) saturation of air.

Vapor Compression Refrigeration Cycle

The Vapor Compression Refrigeration Cycle is nearly 200 years old, but it does not seem ready to leave the scene any time soon. While some people have viewed this method as environmentally harmful and inefficient, the cycle is still applicable in the industrial sphere.

Natural gas plants, petroleum refineries, and petrochemical plants and most of the food and beverage processes are some of the industrial plants that utilize vapor compression refrigeration systems.

VCR cycles have proved to be the trend in modern day cooling technology. This report also compares the economic, technical and adaptive efficiencies of the VCR cycle and Evaporative cooling. A brief explanation on the working of VCR cycles is given below:

II. COMPONENTS OF THE VCR CYCLE

1. Evaporator:

Evaporator is an important component together with other major components in a refrigeration system such as compressor, condenser and expansion device. The reason for refrigeration is to remove heat from air, water or other substance.

It is here that the liquid refrigerant is expanded and evaporated. It acts as a heat exchanger that transfers heat from the substance being cooled to a boiling temperature.

2. Compressor:

A compressor is a refrigerant gas pump in which the evaporator supplies gaseous refrigerant at a low pressure and increases it to a greater pressure. Upon being compressed, the temperature and pressure of the vapor are increased. The gaseous refrigerant is delivered to the condenser at a pressure at which condensation occurs at an appropriate temperature.

3. Condenser:

The purpose of a condenser in the cycle of compression refrigeration is to change the hot gas being discharged from the compressor to a liquid prepared for use in the evaporator. The condenser accomplishes this action by the removal of sufficient heat from the hot gas, to ensure its condensation at the pressure available in the condenser. The heat is shifted to another medium, like water or air, to cool the condenser.

4. Throttling valve or Expansion valve:

Throttling valves are any kind of flow-restricting devices that cause a significant pressure drop in the fluid. Some familiar examples are ordinary adjustable valves, capillary tubes, and porous plugs.

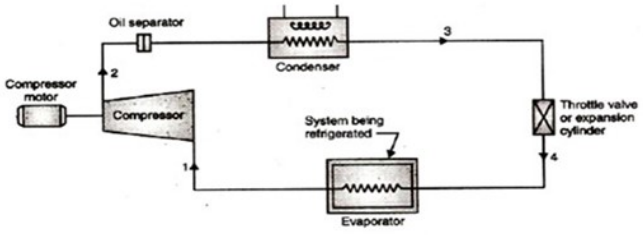

Figure 1. Schematic representation of VCR cycle

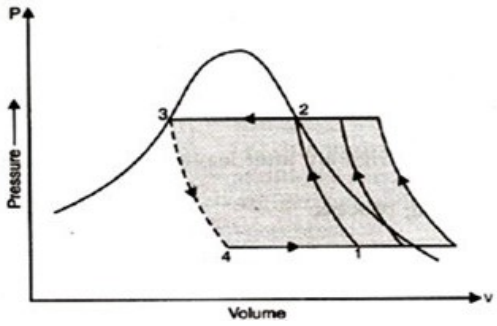

Figure 2. Pressure vs. Volume graph for VCR cycle

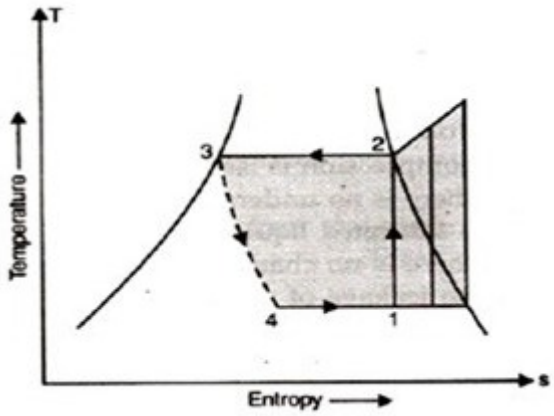

Figure 3. Temperature vs. Entropy graph for VCR cycle

The initial aim of the introduction part of this project is to compare the traditional method used for air-conditioning and Evaporative cooling.

Following are some of the factors upon which both can be compared: -

- Economy
- Energy Efficiency
- Climate Adaptivity
- Quality of Air
- Maintenance Requirement
- Emissions
- Dehumidification
- Limitations for the system in study
- Effect upon surroundings

Simple Air Conditioning

Air conditioning is the process of removing heat from the interior of an occupied space, to improve the comfort of occupants. Air conditioning can be used in both domestic and commercial environments. This process is most commonly used to achieve a more comfortable interior environment, typically for humans or animals; however, air conditioning is also used to cool/dehumidify rooms filled with heat-producing electronic devices, such as computer servers, power amplifiers, and even to display and store artwork.

Air conditioners often use a fan to distribute the conditioned air to an occupied space such as a building or a car to improve thermal comfort and indoor air quality. Electric refrigerant-based AC units range from small units that can cool a small bedroom, which can be carried by a single adult, to massive units installed on the roof of office towers that can cool an entire building. The cooling is typically achieved through a refrigeration cycle, but sometimes evaporation or free cooling is used. Air conditioning systems can also be made based on desiccants (chemicals which remove moisture from the air) and subterraneous pipes that can distribute the heated refrigerant to the ground for cooling.

III. LITERATURE REVIEW

Design and fabrication of solar based evaporative cooling air conditioner

By- Ashwani Sharma- Assistant Professor, Mechanical and Automation Department, Amity University Lucknow**, Tushar Saxena, Priyank Pant, Shantanu Gandhi-** Mechanical and Automation Department, Amity University Lucknow.

Abstract- 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.

A review of evaporative cooling technologies

By- O. Amer, R. Boukhanouf, and H. G. Ibrahim, International Journal of Environmental Science and

Development, Vol. 6, No. 2, February 2015, pages. 111-117

Abstract- 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 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.

Eonomical evaporative air conditioner for Equatorial and tropical regions

By- B.L.Thakor Mechanical Engineering Department, R.C.Technical Institute, Ahmedabad, India

Abstract- Global warming is the prime concern of human being. There are various types of side effects of global warming. Weather of Globe is changing drastically and in erratic manner. Countries on equator and on tropics are facing extreme heat condition due to green house effect. Concentration of greenhouse gases are due industrialization. Average mercury level also shoots up across the globe. To develop comfort condition to scour the heat wave a novel machine has designed which gives the desired comfort level at much lower cost, called an evaporative air conditioner for middle class and lower middle class people.

Performance and analysis of an evaporative cooling system

By- Rajesh Maurya, Dr. Nitin Shrivastav, Vipin Shrivastava, Dept. of Mechanical Engg. University Institute of Technology- RGPV, Bhopal, (M.P.) India.

Abstract- This paper represents working principles, and performance of evaporative cooling technology under broad range of operating conditions. The effectiveness of evaporative cooling in different application can be discussed in this paper and benefits in terms of power consumption, cost savings and environmental impacts, specifically for the facility required to support conventional air-conditioning and the facility required to support space cooled via evaporative cooling. This paper also discusses desiccant assisted evaporative cooling and heat and mass transfer analysis. The superior cooling of air and ventilation can be provided by evaporative cooling system while consuming less energy and also provides environmental friendly cooling technologies.

Energy Conservation through Roof Surface Evaporative Cooling for Air Conditioning System

By-R.B. Lokapure, J.D.Joshi, Dept of Mechanical Engg., Bharti Vidyapeeth College of Engg., Shivaji University Kolhapur, India

Abstract-Day by day the demand of energy is rising tremendously, but there is lack in supply. So, there is no option for proper and efficient utilization and conservation of energy. In this paper the main stress is given on energy conservation by using technique of Roof surface evaporative cooling for Air conditioning system. The target of saving and conserving energy up to 15 to 22% but in this case we achieved our goal of energy saving up to 13% by adopting RSEC technique.

Evaluation of liquid dessicant based evaporative cooling cycles for typical hot and humid climates

By- Sanjeev Jain, P.L.Dhar, S.C. Kaushik

Abstract- This communication presents an evaluation of various liquid dessicant cycles for air conditioning in hot and humid climates. Psychometric evaluation of seven potential cycles for achieving standard comfort conditions (25°C/10 g/kg) in rooms has been

carried out for 16 typical Indian cities. A computer simulation model is based on the constant effectiveness of heat exchangers (HX)/evaporative coolers (EC) and wet surface heat exchangers (WSHE). The absorber-cum-dehumidifier is assumed to provide air at the specified humidity level, while the outlet air temperature is taken to be equal to the cooling water temperature. The effect of various outdoor conditions and the effectiveness of HXs/ECs on cooling COP and volumetric air flow rate per unit cooling capacity have been investigated. It was found that a combination of dehumidifier and WSHE is better, in terms of COP, for a wide range of outdoor conditions. The results should be useful in the design of liquid desiccant based air conditioning systems suitable for the monsoon season in tropical countries like India.

IV. SUMMARY

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.

V. CONCLUSION

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.

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