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A Review on Design and Development of Three In One Air Cooling System

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Abstract - *Over 50% of the greenhouse gas emissions that are produced in our homes are produced by heating, air conditioning and hot water. This puts 2.5 - 5.0 tons of greenhouse gas emissions each year. It also accounts heavy amount of electricity bill every month. In our project we are proposing an innovative solution to the above problems with a new, three in one air cooling system. Humidity can be controlled because of desiccant wheel which cannot be possible by simple water cooling system. Evaporative cooling, desiccant cooling, Heat and Mass Exchanger (HMX) concludes that M-cycle cools down the product air without any rise in humidity. This makes the use of typical solar hot water system and Indirect-direct two stage evaporative cooling system. This system is combination of direct and Indirect evaporative cooling system so it consist both systems advantages with higher values of effectiveness and are more economical in terms of energy consumption saving. Thus, this system can be used as a replacement for mechanical vapor compression systems, leading to decrease electrical energy consumption.*

***Key Words*:Emissions, Solar hot water system, Direct and indirect evaporative cooling, Desiccant wheel, Heat and Mass Exchanger etc.**

1.INTRODUCTION

Electricity is used for many parts of a buildings operation; the largest uses are lighting and air conditioning. Building energy can be saved and pollution decreased while utility expenditures are minimized if energy conservation measures are incorporated into the design, maintenance and operation of a facility. Energy costs will surpass the installed cost of heating and cooling equipment many times over during the life of a typical building. It is important that the design decisions that define a building's lifetime energy use account for the operations cost of a particular system.
The proposed concept of the system consists of an evaporative cooling unit, a solar water heating unit, a heat exchanger, a desiccant wheel as indicated in the block diagram shown in figure 1. In order to determine the characteristics and properties of all the components used, each component must be taken as a single unit.

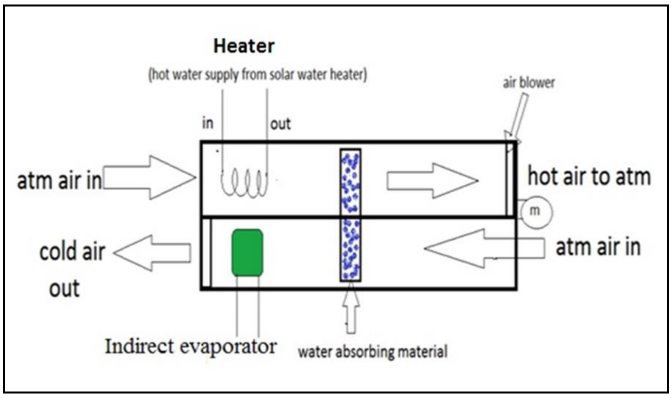

Fig -1: Model Design

1.1 Evaporative Cooling Definitions and Approaches

Evaporative cooling is a process of heat and mass transfer based on the transformation of sensible heat into latent heat. When water evaporates from the surface of something, that surface becomes much cooler because it requires heat to change the liquid into a vapour, known as evaporative cooling[1].

Mainly three type of three type of evaporative cooling systems namely

1. **Direct Evaporative cooling (DEC)**

Direct evaporative cooling is the process of evaporating liquid water to the surrounding air and causing its temperature to decease. A typical direct evaporative cooler, as shown in Fig. no. 2, uses a fan to draw in outside air through a pad wetting media and circulates the cool air through the building.

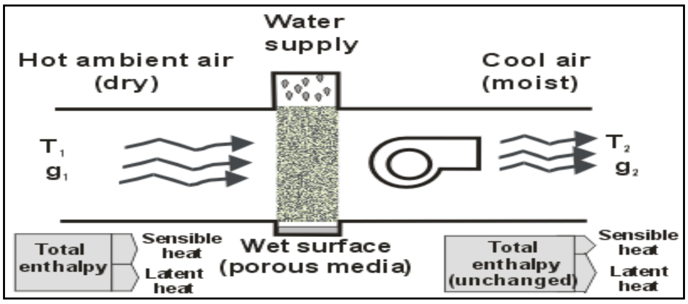

Fig -2 : Schematic of a direct evaporative cooling system[2].

2. Indirect evaporative cooling (IEC) and

In an IEC process the cooled air does not directly contact the evaporating liquid. A secondary airstream flows over the wetted surface so that the liquid water will evaporate and extract heat from the primary airstream through the flat plate or tube wall. In this way, the outdoor air stream is cooled when keeping into contact with the surface through which the heat exchange is produced, without modifying its absolute humidity; whereas at the other side of this surface the secondary air stream is being evaporative cooled. [2]

3. Indirect-direct two stage evaporative cooling system

Indirect-direct two stage evaporative cooling system consists of indirect cooler in the first stage and direct cooler in second stage. Indirect cooling is accomplished with plate type heat exchanger. In an indirect-direct two-stage evaporative cooling system, a direct evaporative cooler is always connected in series after an indirect evaporative cooler to form an indirect-direct evaporative cooler [3].

1.2 Desiccant wheel

The humidification and dehumidification processes of air are important operation in various industrial applications. Also, desiccant cooling system is alternate suitable option against conventional system in humid climatic condition for thermal comfort. The basic constituent of the desiccant cooling system is the desiccant bed. Solid desiccants such as silica gel, zeolites, activated alumina, or hygroscopic salts are generally used to dehumidify moist air, and in such cases, the desiccant is continuously reactivated (regenerated). These adsorbents remove moisture from the air and then the adsorbed water is released in order to regenerate them using thermal energy such us electric heat, solar energy and waste heat. The heat and mass transfer characteristics of the bed have no doubt significant effects on the performance of the cooling system, and should therefore be adequately considered [7].

Silica gel can be desorbed at low temperature which makes it useful for use with solar energy. An investigation on simultaneous dehumidification of silica gel showed that silica gel transfers about 30% more water per unit dry mass than activated alumina [8].

2. LITERATURE REVIEW

"A Review of Evaporative Cooling Technologies", addressed by O. Amaret. et. al.[1] In this paper a review of evaporative cooling technology that could be efficiently applicable in building air-conditioning was carried out. Indirect evaporative coolers showed higher values of effectiveness and are more economical in terms of energy consumption saving. Using water for evaporation as a mean of decreasing air temperature is considerably the most environmentally friendly and effective cooling system.

"Investigation of an Evaporative Cooler for Buildings in Hot and Dry Climates",addressed by R.Boukhanouf et. al.[2] The paper presents a computer model and experimental results of a sub-wet bulb temperature evaporative cooling system for space cooling in buildings in hot and dry climates. Under selected test conditions of airflow dry bulb temperature of up to 45^{o}C and relative humidity of up to 50%, it was found that the supply air could be cooled to below the wet bulb temperature with a maximum cooling capacity of 280 W/m2 of the wet ceramic surface area. Energy consumption in buildings stands at between 30-40% of the total primary energy use globally.

"Experimental Investigation of Two-Stage Indirect/Direct Evaporative Cooling System in Various Climatic Conditions", addressed by Heidarinejad G. et. al.[3] They have studied a multi-step system of nocturnal radiative cooling and two-stage evaporative cooling. The feasibility and potential of this system is investigated for four cities which have different climatic conditions. During the night time in summer, water is circulated from a storage tank to two radiative panels. An energy saving of the multi-step system is between 75 and 79% compared to mechanical vapor compression systems. Consequently, this environmentally-friendly and highly-efficient system can replace the mechanical vapor compression systems. The effectiveness is in the range of 90–120%, but water consumption increases by 55%.

"A Review on Potential of Maisotsenko Cycle in Energy Saving Applications Using Evaporative Cooling" addressed by Chandrakant Wani et. al.[4] This paper reviews the underutilized applications that the Maisotsenko Cycle could have. The constraints set by the conventional vapor compression system are overcome by the use of Maisotsenko Cycle. Direct evaporative cooling is associated with the increased humidity though it gives a fair drop in temperature. On the other hand, humidity is controlled by the indirect evaporative cooling but the temperature drop is not sufficient. Both the systems are coupled in Maisotsenko cycle to form a new system. Opportunities for energy saving will be provided if this newly formed system is utilized properly.

"Experimental analysis on the dehumidification and thermal performance of a desiccant wheel" addressed by Giovanni Angrisani et. al.[5] In this paper, an experimental analysis on this component is presented, with particular attention to the variation of the performance as a function of the process and regeneration air flow rates. The desiccant material is regenerated by means of low temperature thermal energy (about 65^{o}C) from a micro cogenerator. Both the experimental results obtained by the authors and the data provided by the manufacturer have been used to calculate some performance parameters, and a satisfactory agreement has been obtained.

3. Problem Statement

An air cooling system are consuming high energy for their work, emits pollutants (greenhouse gasses) and associated with high energy bills, which is non-affordable to all.

To overcome this problems, renewable energy based air conditioning systems that uses no or minimum amount of electricity and possesses no harm to environment by emitting any kind of harmful gases to the environment or lead to global warming.

4. Objective

a. Design & Manufacturing an alternate air conditioning system for domestic as well as commercial purposes.
b. The system should be based on non-conventional energy sources for minimizing electricity consumption & hence the electricity bill.
c. The system should not make use of harmful refrigerant & should be non-polluting.

5. Heat and Mass Exchanger (HMX)

It is possible to design compact coolers of multiple stages, in each of which the air stream is divided into two new streams. One of these streams is used in an direct evaporative cooling system called as secondry air stream, where the other stream is primary air succeeding in indierct-evaporating cooling rejion where it cooled by conduction and convection in a sensible way, without modifying the initial humidity, using part of the cold air to evaporatively cool the water [3].

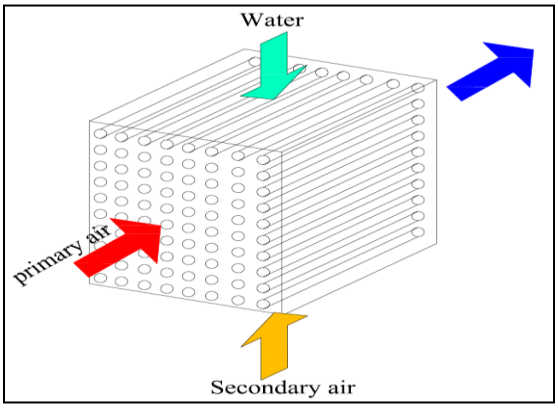

Fig -3: Configuration of a tubular heat and mass exchanger (HMX) [3].

5.1 Manufacturing of HMX

This system consists of series of alternate wet and dry channels as shown in figure 16. In wet channel, cooling is achieved and this cooling effect is then transferred to the dry channel. Through the dry channel, product air flows from where it receives this cooling effect with no addition in humidity [3].

Depending upon the temperature drop required and volume to be air conditioned, the size and number of wet and dry channels are decided.

Manufacturing process of HMX carryout in following three stages:

a. Manufacturing of horizontal plate

Horizontal plate's forms dry channel, which is carries primary air. Manufacturing process of horizontal plate is as follows: Past a cellulose paper on the plastic sheet with water proof adhesive. Mark all dimensions of holes and straw on the plate as specified in design. Make holes on the plates. Stick straws on the plate as per the marking.

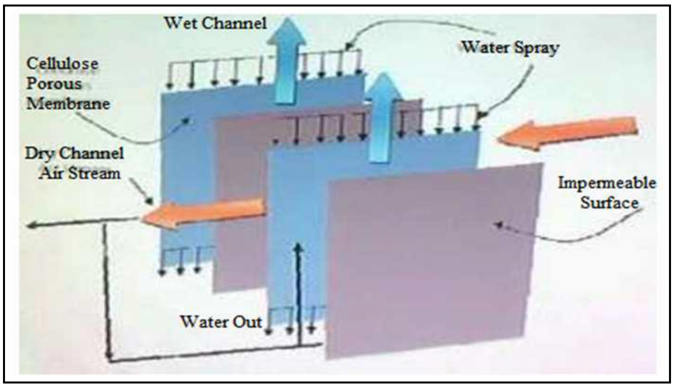

Fig -4: Cellulose porous stack heat exchanger configuration of a HMX [4].

b. Manufacturing of vertical plate

Two vertical plate's forms wet channel, which carry secondary air in HMX. Manufacturing process of horizontal plate is as follows: Past a cellulose paper on the plastic sheet with water proof adhesive. Mark all dimensions of holes and straw on the plate as specified in design. Stick straws on the plate as per the marking.

c. Assembly of HMX

All vertical and horizontal plates are assembled such that two horizontal plate stick together and forms a dry channel and two vertical plate stick together and forms a wet channel. All channel arranged in series of alternate wet and dry channels. Figure 9 shows actual manufactured HMX.

6. CONCLUSION

Using water for evaporation as a mean of decreasing air temperature is considerably the most environmentally friendly and effective cooling system. In this review of Indirect-direct two stage evaporative cooling technology that could be efficiently applicable in building air-cooling.

If we replaced VCC based operating air conditioning system with proposed system it reduces power consumption. Since it works on Maisotsenko Cycle having water as working media it avoid the use of polluting refrigerant used in VCC.

Taking advantage of direct and indirect evaporating combined system as a renewable source of the passive cooling, the hybrid cooling system can be considered as an environmentally clean and energy efficient system.

Thus, this system can be used as a replacement for mechanical vapor compression systems, leading to decrease electrical energy consumption.

7. Future scope

Use of advanced technology and sensors with designed system makes the system automatic and increases its performance with less attention.

By changing material of HMX and heat exchanger with material having high thermal conductivity which directly inverse cooling and heating capacity of the unit.

If electrical heater is installed in the system then system can used throughout the year without interruption for space heating.

8. REFERENCES

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