New Approach Towards Two Stages Evaporative Cooling System

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Abstract— The phenomenon of evaporative cooling system is a generalized practice in nature whose applications for cooling air are being used since the ancient years. It has achievable objective of low energy consumption in comparison with the primary energy consumption of other alternatives for cooling system as this system is based in the phenomenon of reducing the air temperature by evaporating water on it. This paper illustrate critical review and introduction to the thermodynamic basis at which the process is based, as well as the commercial evaporative systems for assisting evaporative cooling system get proposed work and analyze to get higher cooling efficiency with two stage evaporation cooling system where the air is first cooled indirectly by heat exchanger and then passes over pad, which helps to increase humidity, and we get desired cooling effect.

Key words: Two-stage evaporative cooling systems, Direct evaporative cooling, In-Direct evaporative cooling, cooling capacity.

I. INTRODUCTION

The current air conditioning system have very strong influence over mechanical vapour compression systems, which are said to be energy intensive systems and that they suffer from low thermal performance in hot climatic conditions. Therefore there is area of interest in the use of evaporative cooling for the sake of thermal comfort. The initial use of evaporative cooling system was by ancient Egypt and the Roman Empire with the use of wet mats (cooling pads) over doors and windows to cool the indoor air when wind blows through mats. Evaporative kind of cooling system is widely found in Middle East and Persian architecture which often integrated into the wind catchers. Evaporative kind of cooling which has a low carbon content and said to be economically feasible system for cooling buildings in hot and dry climates[1].

The energy requirement for space cooling in buildings in Middle East, particularly in Gulf cooperation council (GCC) countries has increased tremendously from last few decades. It was calculated that on average about 60% of energy use in buildings is for air conditioning system which rises to nearly 80% at its higher times. This is govern by cheap and affordable electrical energy system, increase in the standard of living and tremendous growth in the population[2].

The environmental impact which is associated with the use of energy from conventional fossil originates, the energetic and economic dependency on non-renewable system sources reaching towards the necessity of reducing the energy consumption in day-to-day basis then maintaining the current targets and necessities of activities that require the use of energy system [3].

Evaporative coolers are helps to spread cool air added by enforcement of the hot dry air over a wetted pad. The water present in the pad evaporates then remove the heat from the air while advancement of moisture in to the system. Though this concept had used in residential "swamp" coolers in the Southwest, the technological advancement made the evaporative cooling a perfect alternative to conventional cooling in commercial buildings and in other areas of the systems[4].

Evaporative cooling is said to be environment friendly cooling system and more efficient air cooling method across. The efficiency of evaporative cooling systems varies i.e. basically increases with rise in temperature level and decrease in humidity. So in hot and dry air climates, evaporative cooling helps to save a large amount of energy which is used for conventional air conditioning systems [5].

II. LITERATURE REVIEW

A. *Roy Otterbein:*

Author in this paper briefly explains how the two stage evaporative coolers operate at a fraction of the energy cost of conventional residential air conditioning and helps to keep a home area comfortably cool. Depending upon the design parameter, an evaporative cooler able to use nearly small amount 10% of the energy consumed by refrigeration air conditioning system.

Single stage evaporative coolers have nearly 60% to 85% effective manner in targeting wet bulb temperature. In the region where temperature frequently exceed100°F, the capacity of two stage evaporative is necessarily to meet the higher cooling requirements. Two stage evaporative cooler are generally 100% - 115% effective in targeting wet bulb temperature. It helps to get reduction in the outside air temperature by as much as 50° F while delivering air which is less humid than that from single stage evaporative coolers. [6]

B. *Davis Energy Group:*

This paper describes the facts and advantage of two stage evaporative cooler as compare to single stage cooler. According to author the evaporative cooling establishes a major up forward with the introduction of a two stage model specially designed for residential applications. This unit can best achieved the cooling capacity of a three-ton air conditioner but it uses just 20% of the energy. Three ton refrigerant air conditioners carries energy efficiency Ratio (EER) of 10-12 while the smart coolers have EER ranging from 26 to 56 which carries a peak power demand of 400 watts only as compared with 3000 watt for a three tone air conditioner. Smart cools make uses fresh air and water only and there is no CFCS, HCFCS or refrigerator of any kind.

In replacement of re-circulation of air within the house that unit provides 100% filtered outdoor air. In many of the installation the air is delivered directly through the wall or it may ducted to one or two central place locations. Then air exist the home through vents towards the attic that

cools the attic and further advances in the deduction heat gain.

Smart cool is a kind of two stage evaporative coolers which is also called as Indirect/ Direct coolers. In its first stage incoming air passes through a water covers with heat exchanger that cools without addition of moisture. In its second stage air passes through a water soaked pod in which the temperature drops more in amount and air picks up water laterally which ultimately increases the humidity nearly 70%. As compared with residential coolers, the two stage system increases the overall cooling capacity and maintains the relative humidity between 50 to 65%[7].

C. Oliff & Berridque:

Authors said that two stage evaporative coolers have great potential to provide indoor comfort and simultaneously it reduces energy consumption by replacing traditional vapour compression air conditioning systems in dry to moderate dry climates. "Two Stage Evaporative Cooler" compiles with more cooling capacity than traditional single stage (i.e. direct) evaporative coolers and contains less moisture to the condition space. A two-stage evaporative cooler does not make the use of a compressor so they have significantly more energy efficiency than traditional air conditioning system. Two-stage evaporative coolers have high cooling capacity and relatively low moisture addition. Social advantages by mitigating the environmental damages which are associated with conventional air conditioning system. Two-stage evaporative cooler unit are most effective at reducing use of electricity during summer afternoon house, when most of the other utilities fall peak requirement[8].

D. Ray Dabry (Davis Energy Group):

Ray Dabry in his paper said that two stage evaporative cooler can cool the air to lower temperature range than which are achievable with direct (one stage) evaporative cooler with having less moisture to the indoor air. The original two stage evaporative cooler unit designed by Davis Energy Group was developed 1999-95 in association of 45% match support from the Energy commission's energy Technologies Advancement Programmed (ETAP). In there experimental work, a monitored field test imparts that the two stage evaporative cooler is six times more efficient than conventional cooling and their all application are satisfied with two stage evaporative cooler comfortably[9].

E. W. V. Saman And S. Alizandeh:

The author in this paper investigated experimentally & numerically that the thermal and dehumidification behaviour of a standard cross flow plate heat exchanger are supposed to intended for the use as a dehumidifies/cooler. Experiments was carried out where air is blown in to the primary and secondary sides of the exchanger where water and liquid desiccant were being passes in a counter flow arrangement. The first set was contain with water only which was being sprayed into the secondary air stream with different air masses flow rate and variable heat exchanger angles. The second set was with the liquid desiccant only which passed into the primary air stream for various primary air mass flow rates and variable heat exchanger angles. In the third set of experimentation, the primary air stream was indirectly evaporative which was cooled by the secondary air stream and dehumidified by the liquid desiccant passed in to the primary side of the exchanges. These experiments indicated that the heat exchanger have great performance ratio when uses with liquid desiccant and for an exchanger angle of 45% there was an optimum value of air mass flow rate where the effectiveness and dehumidification efficiently of the plate heat exchanges is at max[10].

III. EVAPORATIVE COOLING TECHNOLOGY

Evaporative cooling technologies can be classified into two kind's i.e. direct and indirect system:

A. Direct Evaporative Cooling Systems:

Direct evaporative cooling is consist of evaporating liquid water to the surrounding air and then causing its temperature to decease. Direct evaporative cooler, as shown in Fig. 1, makes the use of a fan in order to draw into the outside air passing through a pad wetting media and then circulating the cool air through the building.

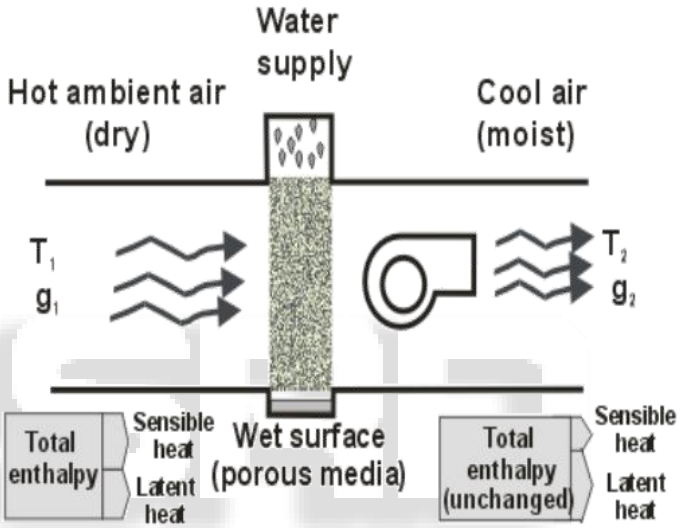

Fig. 1: Schematic of a direct evaporative cooling system

The energy which is required for evaporation of water get provided by the air, though at the cost of increasing its moisture content level and decrease in its temperature range. As the process is adiabatic, the sensible heat loss by the air gets balanced by latent heat gain that appears as moisture content increase.

B. Indirect Evaporative Cooling And Sub Wet Bulb Temperature:

This contains more researcher in order to develop and modify the thermal process associated with direct evaporative cooling system in order to achieve sub-wet bulb temperature which is referred to as Dew point or Sub-wet bulb temperature evaporative cooling. The benefit of this kind of arrangement is that the moisture content of the cooled air remains unchanged ever. In this kind of coolers arrangement firstly the air streams are separated into dry channel for supply air and then wet channel for retrieving spent working air. The supply air in the dry channel get cooled indirectly by translating its heat into the working air in the wet channel through a thin non-permeable channel wall. To obtain sub-wet bulb temperature, part of the cool air in the dry channel is converted to get the desirable evaporation process in the wet channel, as shown in Fig. 2.

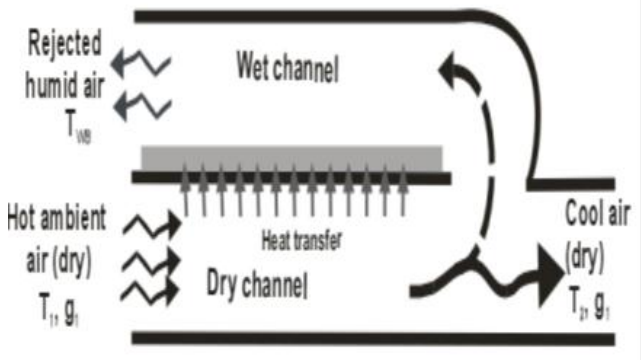

Fig. 2: A simple schematic of a sub wet bulb temperature indirect evaporative cooler.

C. Wet Media Materials:

The wet media get use in the evaporative coolers is mandatory component of an evaporative cooler. It is generally made up of a porous material having large surface area and capability to hold liquid water. The selection criteria for wet media materials is depends on their effectiveness, availability, cost, safety, and environment factors etc. Various kinds of porous materials such as metal and plastic foams, zeolite and carbon fibres can be used as wet media for heat and mass transfer in evaporative cooling systems.

IV. APPLICATIONS

(1) It is useful in residential applications in case of hot and dry climates (where the mean coincident wet-bulb temperature is below 70°F).
(2) Other applications which require large amounts of fresh outdoor air includes modular classrooms, gymnasiums, and commercial kitchens for this technology.
(3) Evaporative air conditioning is also popular and well-suited to the southern (temperate) part of Australia.
(4) Industrial plants, commercial kitchens, laundries, dry cleaners, greenhouses, spot cooling (loading docks, warehouses, factories, construction sites, athletic events, workshops, garages, and kennels) and confinement farming (poultry ranches, hog, and dairy) also makes the use of evaporative cooling.
(5) Evaporative cooling is generally used in cryogenic applications.

V. FUTURE SCOPE

Complete air conditioning gives a environment of correct temperature, air movement, humidity ratio, air cleanliness, proper ventilation and noise level. Thus it is often a very critical decision for design engineer to select a correct air conditioning system for given space to be conditioned. Present status cooler has more scope for improving cooling capacity and overall efficiency of system. As the pad used is not durable the pad having same functioning and long life have to be used. The aluminium pad can be a solution to this problem by using air filters and cooling coil with Fins.

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