Study, Design and Analysis of Two Stages Evaporative Cooling System

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Abstract— In this paper we have studied an assisted evaporative cooling system is design and analysis to get increases in cooling efficiency to get hot environment and reducing a mint of moisture added to air. Evaporative cooling is responsible for the chill you feel when a breeze strikes your skin the air evaporates the water on your skin, with your body heat providing the energy. The ancient Egyptians hung wet mats in their doors and windows, and wind blowing through the mats cooled the air the first attempt at air conditioning. This basic idea was refined through the centuries: mechanical fans to provide air movement in the 16th century, cooling towers with fans that blew water-cooled air inside factories in the early 19th century, swamp coolers in the 20th century. In Two stages evaporative cooling are also known as "Indirect and direct "cooler. In the first stage, incoming air passed through a heat exchanger that can be cools the air without adding moisture. In second stage, air passes through the water soaked pad where the temperature dropped more and air to be pick the water which is increasing the humidity. Here, in this cooling system incoming hot air is first passed through the cooling pad that is heat exchanger when temperature of air to be decreases and this air is again passing through the cooling medium and then evaporated into the atmosphere. so, two stage evaporative cooling system is an smart cooling as considered as an cost factor and power saving.

Key words: Evaporative Cooling System, Indirect Evaporative Cooling System

I. INTRODUCTION

A 2-stage evaporative cooling system (aka" indirect\direct 'cooling) represents the most economical cooling system – utilizing evaporative cooling technology. This cooling option is much more energy efficient than cooling with refrigerant (standard air conditioning), but it's not suitable for all cooling applications. 2-stage evaporative cooling in terms of the stage of cooling that occurs. In the first stage, hot outside air passes inside the heat exchanger that is cooled by evaporation on the outside During this initial cooling phase, the incoming air stream doesn't pick up any extra moisture. In the second stage, the same air stream passes through a water-soaked pad where the additional cooling takes place and the air picks up some additional humidity. A 2-stage evaporative cooling system can deliver cool indoor air with a relative humidity in the 50%-65% range, while direct system typically condition the air at around 70% relative humidity.

According to the American, Society of Heating and Engineers (ASHRAE),advanced two stage evaporative coolers can use 60%-75%less electricity than conventional refrigerant-based AC system. While this makes evaporative cooling a very attractive option in terms of energy efficiency, it's important to note that that this system are best-suited for the hot, dry climate found in the American Southwest. An evaporative cooler (also swamp cooler, desert cooler and wet cooler) is a device that cools air through the evaporation of water, evaporation cooling differs from typical air conditioning systems which use vapor compression absorption refrigeration cycles. Evaporative cooling works on the principle of employing water's in large enthalpy of vaporization. The temperature of dry air is to be dropped significantly through phase change to liquid water to water vapor (evaporation),which could be cool air with the help of much less energy than refrigeration. In dry climates, evaporative cooling of air has added in conditioning the air with large amount of moisture for the comfort of building occupants. The cooling potential of evaporative cooling is dependent on the wet bulb depression that is the difference between dry bulb temperature and the wet bulb temperature. In arid climates condition the evaporative cooling can be reducing energy consumption and total equipment for conditioning as an alternative to compressor based cooling. In climates not considered arid, indirect evaporative cooling can sill take advantages of evaporative cooling process without increasing humidity.

II. LITERATURE REVIEW

A. Metin Petek and Serdal Dikmen:

In his paper said the cooling performance of a traditional (control) and two stage evaporative pad cooling system (experiment), consist of pad and fan with tunnel ventilation, for poultry houses and the growth performance of broilers reared in these systems was compared in a study performed during extreme summer temperatures. The experimental unit had a two stage pad cooling system, which consists of underground tubes and box, followed by a pad cooling system with tunnel ventilation. Air temperature, relative humidity, and saturation efficiency is used to be determine by the cooling performance of the systems. Live body weight gain, feed conversion ratio, and mortality rate were used to monitor the growth performance of broilers raised in these systems. The air temperature and relative humidity of incoming house and exhausted air in the two stage cooling pad system is found to be significantly lower than of the traditional system ($P < 0.05$). The cooling efficiency or saturation efficiency in the two stage cooling system is found to be slightly greater than that of the traditional system. Body weight gain was also significantly influenced by the cooling system ($P < 0.05$). The results indicated that two stage pad cooling is a more efficient method to be alleviating heat stress in broilers during heat stress conditions and to improve growth performance.

B. J.T.Liberty, W.I.Okonkwo and E.A.Echieges:

In his paper said that evaporative cooling occurs when an air not to be humid, and passes over the wet surface, which results in faster the rate of evaporation and greater cooling. Efficiency of the evaporative cooling structure is to be depends upon humidity of an surrounding air. In an evaporative cooler reducing the storage temperature and also increases relative humidity within an optimum level of storage there by keeping the fruits and vegetable can be fresh. Therefore, evaporative cooling is an low cost technology for the purpose of fruits and vegetables. The evaporative cooling is cost effective and can be used prolong shelf-life of agriculture produce.

C. J.K.JAIN, D.A.Hoindoliya:

In this paper presents development and testing of a regenerative evaporative cooler. A conventional direct evaporative cooler is to be modified by an addition of water to an air, heat exchanger in the path of outgoing air stream. The heat exchanger is to be cools the air further by using cooled water available in the collecting tank. Experiments are to be conducted to study the performance and analysis of the regenerative evaporative cooler. It to be found that the efficiency and COP of regenerative system increases by 20-25%. The regenerative cooler having higher cooling capacity may be advantageous as it may attracting more people for maximum utilization of this low energy consuming device leading to energy conservation in the purpose of residential and commercial buildings.

D. Abdulrahman Th.Mohammad, Sahif Bin mat:

In his paper said that the experimental investigation on the performance of direct evaporative cooling is hot and humid regions. The experimental study is based on weather data from Kuala Lumpur and Malaysia. The direct evaporative cooler is to be consists of a cellulose pad with a surface area per unit volume ratio of 100 m2/m3. The performance of the evaporative cooler is evaluated using the output temperature, saturation efficiency, and cooling capacity. The output temperature of an air varies in between 27.5°C and 29.4°C, and also cooling capacity is between 1.384 kW and 5.358 kW.

E. Azhar Kareem Mohammed:

In his paper said that, space cooling is a major source of energy is use such that during summer months, performance of two stage evaporative cooling system is experimentally investigated in an various simulated climatic condition. Two stage evaporative cooling consist of indirect evaporative cooling system and direct evaporative cooling system. Due to various climatic conditions in Erbil, results in various outlet condition the effectiveness in IEC stage varies in between (55-65) % and the effectiveness of two stages IEC/DEC varies in between a range of (90-110) %. An evaporative comfort zone, this system providing comfort zone in erbil-iraq where the direct evaporative is not to be providing summer comfort condition .In evaporative cooling system can be more than 60% power saving with an mechanical vapour compression system with just 55% to increases water consumption with respect to direct evaporative cooler. Final output temperature of an air in two stage modes IEC/DEC varies in the range in between 23°to 25°.

F. Dr. Sam C.M.Hui and Ms .W.Y.Cheung:

In this paper working would be explain the working principle of two stage evaporative cooling system and their performance in hot and humid climate. Evaporative cooling is environmentally and energy efficient cooling system that can be used water as a working fluid to cool air through simple evaporation of water .It is an technology could reduce air conditioning cooling energy requirement in building and providing environmental benefits. Therefore, direct evaporative cooler increases humidity of air to a level occupant uncomfortable under humid climatic conditions. Two stage evaporative cooler can be improved efficiency and reducing amount of moisture added to the air. Efficiency of system depends on system configuration component design and control strategies.

III. METHODOLOGY

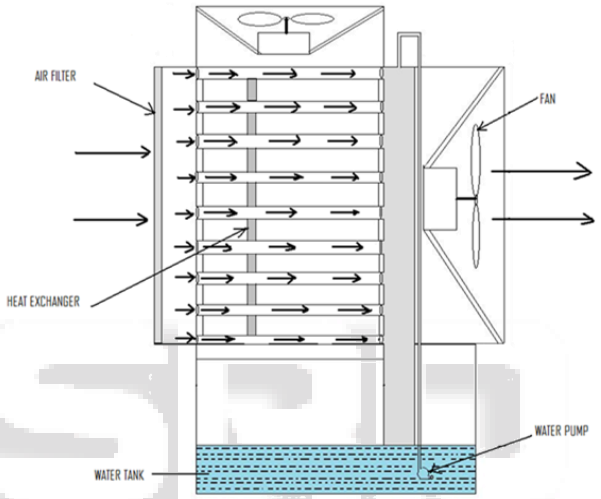

Fig. 1: Methodology

IV. 2STAGE OF EVAPORATIVE COOLING SYSTEM

An evaporative cooling system is an air conditioning system in which air is evaporated cooled just like how, the body perspires on a hot day and this moisture evaporates into the air in contact with our skin Because the evaporation process absorbs heat, in our skin feels to be cool. The air is to be faster the moves over the skin, the cooler one feels. An ideal evaporative cooler basically consists of a wetted medium, a fan (which is usually a centrifugal fan to provide the required system total pressure loss and a lower noise level), and a sump at the bottom. For, water spraying systems, a circulating pump and piping connection are needed to distribute water evenly. A float valve replenishes water lost through evaporation and also allows for a constant bleed to dilute and flush out insoluble mineral salts accumulating in the sump. Evaporative system consist of two tanks first is mounted at the lower position called lower tank and another is mounted at the top pest position of the system hence is called as upper tank. first the outside hot air is to be comes in input passage and pass into the cooling pad that is heat exchanger then lower tank of water is be sprayed in this cooling pad hence the temperature of this air is to be decreases. This process is called as direct evaporative cooling system. In an second stage this lower temperature air is to be again passed through the heat exchanger process

cooling pad which results in required cools air in output fans. This process is called as indirect evaporative cooling system.

V. TYPES OF EVAPORATIVE COOLING SYSTEM

A. *Direct Evaporative Cooling System:*

In direct evaporative cooling outside air is blown through a water saturated medium (usually cellulose) and cooled by evaporation. The cooled air is circulated by a blower. Direct evaporative cooling adds moisture to the air stream until the air stream is closed to the saturation. The dry bulb temperature is reduced, while the wet bulb temperature stays the same. Dry bulb: sensible air temperature is measured by a thermometer. Wet bulb: the lowest air temperature achievable by evaporating water into the air to bring the air to saturation.

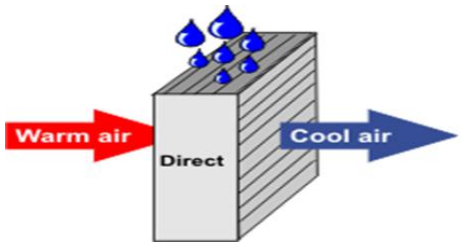

Fig. 2: Direct Evaporative Cooling System

B. *Indirect Evaporative Cooling System:*

In indirect evaporative cooling, a secondary (scavenger) air stream is cooled by water. The cooled secondary air stream goes through a heat exchanger, where it cools the primary air stream. The cooled primary air stream is circulated by a blower. Indirect evaporative cooling does not add moisture to the primary air stream. Both the dry bulb and wet bulb temperatures are reduced. During the heat season, an indirect system's heat exchanger can preheat outside air if exhaust air is used as the secondary air stream.

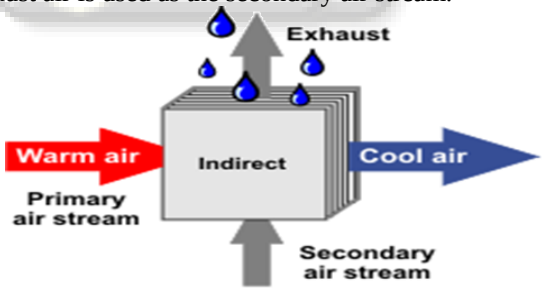

Fig. 3: Indirect evaporative cooling system

C. *Indirect/Direct Evaporative Cooling:*

In indirect/direct evaporative cooling the primary air stream is cooled first with indirect evaporative cooling and then cooled further with direct evaporative cooling.

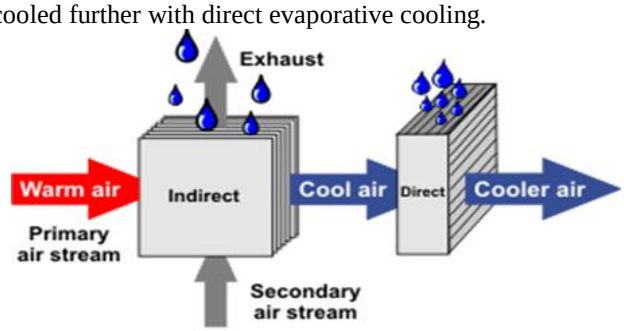

Fig. 4: Indirect/Direct Evaporative Cooling

D. *Indirect/Indirect Evaporative Cooling:*

In the first stage, the primary air stream is cooled by indirect evaporative cooling .In second stage, water used in first stage cooling passes through the wet side of a coil. Additional sensible heat is removed from the primary air stream, and no moisture is added to the primary air.

E. *Indirect evaporative Cooling/DX:*

In an indirect evaporative cooling with DX back up, the primary air stream is cooled first with indirect evaporative cooling. Most of time, this cools the primary air stream to the desired temperature. When more cooling is required the supplemental DX module cools the air further to reach the desired temperature. This unit is in beta release, and achievable energy saving are still being tested.

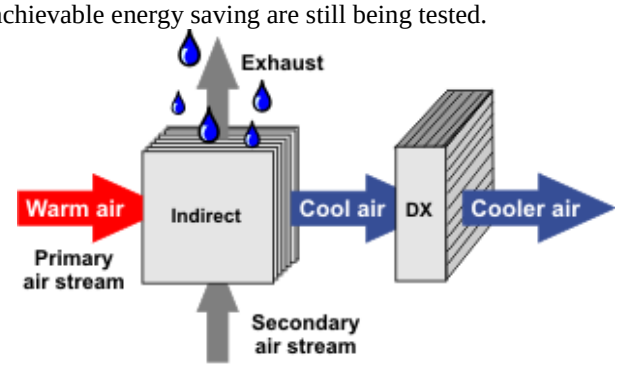

Fig. 5: Indirect evaporative cooling/DX

F. *Advantages:*

- Two stages cooling allow the use of energy saving evaporative cooling technology for design condition where direct evaporative cooling is inadequate.
- The energy consumption is around half than that of air conditioning, while the capital cost is also significantly lower.
- In many cases two stage system can provide better comfort than a compressor based system because they maintain a more favourable indoor humidity range. Hence they can replace mechanical refrigeration in many applications.
- The conditioned space is cooled by 100% fresh air hence there are no IAQ related problems. Typically two stage cooling systems are designed for 25 to 40 air changes per hour similar to ventilation.
- Since no refrigerant is used the system environmentally friendly.

G. *Disadvantages:*

It is less effective in coastal areas which have high relative humidity.

There is a significant temperature variation in the cooled space round the year depending on the prevailing ambient dry and wet bulb temperature.

VI. CONCLUSION

- It is most widely used in summer season.
- It can most advantage of these is to be save water in 5 or 6 days.
- It is energy consumption.
- Higher ventilation rates also help to lower the indoor temperature.

– Indirect evaporative cooling is an interesting passive cooling technique in which the thermal performance depends mainly on the indoor humidity

VII. FUTURE SCOPE

Air conditioning gives a environment to correct temperature, air movement, air cleanliness, humidity ratio, 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. It 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.

The polluted and unfiltered air is also a problem this can also be avoided how The noise of the system is also can be reduced by using noiseless fans as the drop in DBT of the ambient air limited by the WBT of the ambient air and humidity of the air the humidity of the air cooler by evaporative cooling is considerably large. This draw back can be removed by initial cooling of air by some means like heat exchanger.

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