Review on Performance of Direct Evaporative Cooler

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Abstract— Demand for electric power during peak periods in summer is a vital concern for many utilities in the fast-moving world. From the demand point of view on the grid and cost to the consumer, it is quite wise to install, energy efficient evaporative coolers rather than conventional air conditioners. Evaporative cooling has a great many advantages over other cooling processes. Due to the non-pollution creating environment, it is considered as one of the suitable ways to cool ones workplace or living place because of the fact that it uses fresh air and replaces the air time to time, quite frequently, an hour. Due to recirculation of air, smells and allergens are expelled. It bases on a natural process of air cooled by water, it won't dry out the air, or irritate human skin, eyes, or other external parts of the human body. It allows the doors to be left open for one to sustain the heat of summer. Moreover, evaporative cooling is an inexpensive cooling option which enhances the lifestyle of people. However, evaporative cooling requires an abundant water and is efficient when the relative humidity is low. Padding media play a major role in determining cooling efficiency the comparative performance of Desert Coolers employing four different pads in terms of cooling efficiency, air velocity, and water consumption for a sustainable and economic application. In real practice, we use aspen, coconut coir, as cooling pads in desert coolers.

Key words: Evaporative Cooling, Cooling Pad, Cooling Efficiency, Coconut Coir & Aspen

I. INTRODUCTION

There is growing demand for space cooling in hot climates as people spend most of their days indoors. To a very large extent, the quality of lives of human beings depends on the quality of their indoor environment. Thermal comfort is defined as the condition of mind that expresses satisfaction with the thermal environment. Therefore, the provision of thermal comfort for the user of buildings is fundamental. The conventional refrigerated-based air conditioning systems are the systems commonly used for providing thermal comfort for occupants of a living space. But in most developing countries of the world, the use of these systems is impeded by the epileptic power supply and the high cost of the systems.

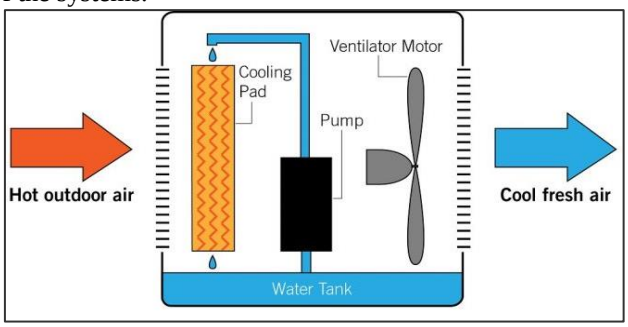

Fig. 1: Direct Evaporative Cooling System

They are relatively expensive for the common man They are not fully utilized in areas where the power supply is epileptic and constantly interrupted They are characterized by poor indoor air quality because of the use of recirculated air .Evaporative coolers are suitable alternative to refrigerated-based air conditioning systems. In this system, the natural effect of evaporation is used to remove the heat from the air of the living space. Unlike the refrigerated-based air conditioning systems, the evaporative coolers have the following advantages: Unlike most refrigerated cooling systems that rely on recycled cooled air with partial fresh air replacement, the evaporative cooler enjoys popularity in the introduction of a continuous supply of freshly cooled outdoor air. These creations of healthy invigorating conditions generate a feeling of relaxed enthusiasm, conducive to improve people concentration and work output. This is due to the naturally cooled, humidified, negatively ionized air which does not dry up nasal passages, eyes or skin, unlike the positively ionized, artificially cooled air from a refrigerated based air conditioning Helps maintain natural humidity levels, which benefits both people and furniture and cut static electricity Does not need an air-tight structure for maximum efficiency, so occupants can open doors and windows The working fluid, water, does not have negative impacts on the environment and it is relatively available and cheap The technology of evaporative cooler is simpler, the cooler costs about 80 per cent less than refrigerated based air conditioner that will cool the same area. The installation costs of evaporative coolers are comparable to conventional air conditioning. Evaporative coolers can be direct, indirect or direct-indirect systems. Apart from the climatic region where the evaporative cooler is to be used, one significant factor that determines the performance of an evaporative cooler is the type of the evaporative cooling pad used.

Different evaporative cooling pads have a different water retention capacity which is attributable to the different structural features of the pad. Therefore, the performance of evaporative coolers to a reasonable degree is hinged on the saturation effectiveness of the evaporative cooling pad material. This Experiment attempts to analyze the performance of coconut coir as media in direct evaporative cooler.[1-4]

II. HISTORY OF EVAPORATIVE COOLER

Evaporative cooling is a physical phenomenon in which evaporation of a liquid, typically into surrounding air, cools an object or a liquid in contact with it. Evaporative cooling occurs when air, that is not too humid, passes over a wet surface; the faster the rate of evaporation the greater the cooling. There have been various designs over the years. In early Ancient Egyptian times, paintings depicting slaves fanning large, porous clay jars filled with water which is essentially is a very, very early form of evaporative cooling.

The first man made coolers consisted of towers that trapped wind and funnelled it past water at the base and into a building. This in turn kept the building cool at the time. (dualheating.com).

In 1800 B.C the new England textiles factory began to use the evaporative cooling systems to cool their mills (www.evaprocool.com). In the 1930's the Beardmore tornado airship engine used to reduce and completely remove the effect of using a radiator which reduces the effect of lag.(coco.cooler.com) Bamboo coolers were constructed with bricks with hessian cloth which were used to wrap the bricks. Also, charcoal coolers were also produced together with the Almirah coolers. Rusten, (1985) described some types of evaporative cooling that was been used in New Delhi, India in which a wetted mat with fan was used to cool a local restaurant. The concept of water-cooling a roof has a long history but it is estimated that less than 60 million square feet of roof have ever been water cooled (Tiwari et al., 1992). It was also reported that if only a small amount of water is placed on the roof, the evaporation is highly accelerated as compared to what would be if the roof surface was flooded (Carrasco, 1987).[3]

III. METHODOLOGY

In evaporative cooling process the water evaporation or any other fluid according availability in case of draught, with a following chilling of the air. These systems have great significance to provide thermal comfort in spaces where the dry bulb temperature is high. Direct evaporative cooling apparatus cool the air by direct contact with a liquid surface or with a wet solid surface, or even with sprays. In this system the water vaporization takes place because of dry hot air which is drawn by fan and thus the temperature of the hot air decreases and this air is blown in to the confined spaced for the requisite purpose, during this process dry bulb temperature is decreased substantially and thus humidity is increased. The efficiency of an evaporative cooler is the rate between the real decreasing of the dry bulb temperature and the maximum hypothetical decrease that the dry bulb temperature could be if the equipment was 100 percent efficient and the outlet air was saturated. In this case, the exit dry bulb temperature would be equal to the wet bulb temperature of the inlet air. To perfect evaporative cooler the dry bulb temperature and the dew point might be equal to the wet bulb temperature.[2-307]

The methodology includes:

- Fabricate the evaporator cooler by considering all the component like water tank, motor, fan, water pump and pad material.
- Formed experimental set up.
- Experimental test carried out to evaluate performance of evaporative cooling unit.
- To determine the air temperature and relative humidity inlet and outlet point as well as considering different pad material and air flow rate.
- Calculate the cooling efficiency of evaporator cooler with different padding material

IV. TYPES OF EVAPORATIVE COOLING SYSTEMS

Two principle methods of evaporative cooling are:

1) Direct cooling

In direct cooling water evaporates directly into the airstream, thus reducing the air's dry-bulb temperature while humidifying the air.

2) Indirect cooling

In indirect cooling, one stream of air called primary air is cooled sensibly (without addition of moisture) with a heat exchanger, while the secondary air carries away the heat energy from the primary air. Direct and indirect processes can also be combined (indirect/direct). The effectiveness of either of these methods is directly dependent on the low wet bulb temperature in the supply airstream.[7-308]

A. Direct Evaporative Cooling (Open Circuit)

Direct evaporative cooling introduces water directly into the supply airstream (usually with a spray or some sort of wetted media). As the water absorbs heat from the air, it evaporates and cools the air. In direct evaporative cooling the dry bulb temperature is lowered but the wet bulb temperature remains unchanged. In operation, a blower pulls air through a permeable, water-soaked pad. As the air passes through the pad, it is filtered, cooled, and humidified. A recirculation pump keeps the media (pad of woven fibers or corrugated paper) wet, while air flows through the pad. To ensure that the entire media is wet, more water is usually pumped than can be evaporated and excess water drains from the bottom into a sump. An automatic refill system replaces the evaporated water.

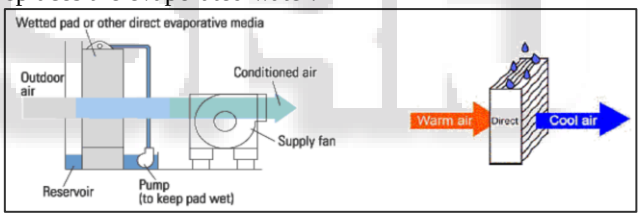

Fig. 2: Direct Cooling

The efficiency of direct cooling depends on the pad media. A good quality rigid cellulose pad can provide up to 90% efficiency while the loose aspen wood fiber pad shall result in 50 to 60% contact efficiencies.

B. Indirect Evaporative Cooling (Closed Circuit)

Indirect evaporative cooling lowers the temperature of air via some type of heat exchanger arrangement, in which a secondary airstream is cooled by water and which in turn cools the primary airstream. The cooled air never comes in direct contact with water or environment. In indirect evaporative cooling system both the dry bulb and wet bulb temperatures are reduced. Indirect evaporative coolers do not add humidity to the air, but cost more than direct coolers operate at a lower efficiency. The efficiency of indirect cooling is in the range of 60-70%.

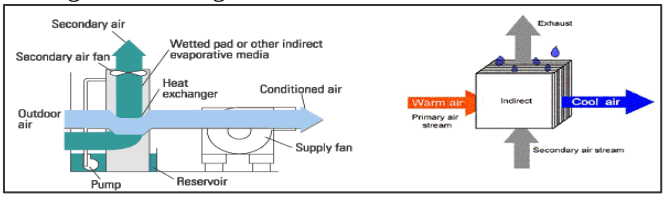

Fig. 3: Indirect Cooling

V. APPLICATIONS

A. Air Conditioning

The main application of evaporative cooling is the air-conditioning of premises in hot and arid regions. Humidification of excessively dry air improves comfort to an extent: when it is hot, the human body's thermal regulation depends precisely on evaporative cooling as perspiration is the evaporation of water through pores and this natural regulation process is hindered when the air is too humid. It is generally considered that human thermal comfort conditions are met when the temperature is between 20 and 27°C and relative humidity between 30 and 65-70%.However, the definition of the conditions of temperature and humidity considered "comfortable" for the human body depends at least to an extent on individual perception.

B. Storage of Perishable Foodstuffs

In hot countries, evaporative cooling cannot achieve the temperatures recommended for products of animal origin or for most of the products of vegetal origin. However, in some cases, it may allow a significant slowdown of the deterioration process of tropical fruit and vegetables, thus making possible an appreciable gain in terms of shelf life and marketing periods. The increase in relative humidity reduces the wilting and weight loss by evapotranspiration of fruit and vegetables, but an excess of relative humidity encourages the proliferation of unwanted organisms, including fungi (botrytis, penicillium...) resulting in the deterioration of the products, or even in the production of bio-toxins. For the preservation of fruit and vegetables, recommended humidity is generally 85-95%. The risk of corrosion of metal parts is also to be taken into consideration.

C. Pre-Cooling

When evaporative cooling does not achieve the desired temperatures, in some cases, it can be used for pre-cooling operations, so as to reduce the energy consumption of conventional devices used to achieve the temperatures required, as well as the sizing of these devices, thus allowing for lower operation and investment costs.

VI. ADVANTAGES & DISADVANTAGES

Based on available information of direct evaporative cooling system different advantages and disadvantages can be summarized as follows

A. Advantages

- The main advantages of evaporative coolers are their low cost and high effectiveness.
- Permitting a wide range of applications and versatility in the buildings, dwellings, commercial and industrial sectors.
- Direct evaporative devices act like filters, removing dust particles in air.
- It requires no special skill to operate and therefore is most suitable for rural application.
- It can be made from locally available materials.
- Highly efficient evaporative cooling systems that can reduce energy use by 70%.
- Less expensive to install and operate.
- It can be easily made and maintained.

B. Disadvantages

- The water consumption associated to the operation of these systems, which is ascarce resource in dry and hot climates, where these systems best work.
- Evaporative cooling system requires a constant water supply to wet the pads. Therefore, need to be watered daily.
- Space is required at outside the home.
- Water high in mineral content leave mineral deposits on the pads and interior of the cooler gets damaged.[2,10]
- DEC is only suitable for dry and hot climates. In moist conditions, the relative humidity can reach as high as 80%, such a high humidity is not suitable for direct supply into buildings, because it may cause warping, rusting, and mildew of susceptible materials.

VII. CONCLUSION

An experimental analysis of direct evaporative cooler by varying materials of cooling pads is performed. The cooling pads of materials such as Aspen wood wool and coconut fibers are used in the model of cooler for doing the analysis. Efficiency of combination of two different cooling pad (Aspen & Coconut) is more than that of separate aspen and coconut cooling pad. Humidity of coconut cooling pad is less than as compare to combination of two different cooling pad (Aspen & Coconut) and separate aspen cooling pad. Water consumption of coconut cooling pad is less as compare to combination of two different cooling pad (Aspen & Coconut) and separate aspen cooling pad.

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