Study to improve the performance of Solar Evaporative Cooler by using Cellulose Pad

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Abstract
Evaporative cooling is considered a cheap method using in many different life applica-.tions. This type of cooling is suitable for hot and dry regions
The aim of this study is to improve the performance of solar evaporative air cooler by using new cellulose pad. An ordinary evaporative air cooler (60x60x70) cm, gives (0.39) m3/s of air was used, it operate in baghdad city using 10 cm thickness of aspen wood pad and measurement of temperature and humidity was recorded and then the pad was changed by cellulose, the temperature and humidity was recorded again. After calculation of humidifying effectiveness of air cooler for two pervious conditions, the results indicate an improving in humidifying effectiveness by (20,3-58.4)% and (23.6-51.2) % of tem-.perature difference when using cellulose pad

1-Introduction

Concern about urban air pollution, oil leakage, nuclear dangers, and global warming prompts the search for alternatives to coal, oil and nuclear energy, and although alternative energy sources are not generally pollution-free, there are many options whose envi-.ronmental damage is much less than conventional energy sources
The most promising technologies are those that harness the energy of the sun. The direct thermal conversion of solar radiation into electrical energy through solar cells is a new and advanced technology. It is a strategic industry as a future source of energy that will have the greatest impact in reducing the use of traditional energy sources and reducing .gaseous emissions affecting global warming. Global
Air conditioning for the purposes of providing comfort in residential buildings is one of the necessary things in people's daily life and requires high electrical energy, especially the compressive type of air conditioning, and solar cells cannot provide it at a low cost at the present time, as it provides photo conversion of solar energy into electrical energy of up to 800 watts / hour, (1) Therefore, attention was drawn to the use of direct evaporative cooling to provide a relatively comfortable air-conditioning for residential buildings, because it does not require high electrical energy, in addition to the suitability of Iraq's climate to be used because Iraq's climate is hot and dry in summer in most areas, where

an evaporative cooler was used that works On the continuous electric energy generated .from solar cells stored in dry-type batteries for this purpose

Several theoretical and practical studies have been conducted to show the effect of various factors affecting the efficiency of direct evaporative cooling.(2)(Kulkar conducted a practical study in India of the effect of the pad material on the cooling efficiency, where he used pad of solid cellulose, aspen wood fibers and high density polyurethane. The study showed that the aspen wood fibers achieved a cooling efficiency of 87.5%, and solid cellulose, the efficiency of 77.5%, and the achieved temperatures ranged between 26.5 to 28.5 ° C in a hot and humid environment. (3) (Kashhwada & Subas) conducted a study to measure the performance of the wet pad and The effect of its thickness on cooling efficiency, where the study showed an increase in efficiency by increasing the thickness of the pad, (Changuang & Aguw) (4) conducted a study of the effect of the inlet dry temperature and the face velocity of the inlet air and the inlet water temperature on .the cooling efficiency

Fouda & melikyan) (5) conducted a comparative study between the mathematic model) and the laboratory results of direct evaporative cooling, where the results showed that the cooling efficiency decreases with the increase in the velocity of the incoming air and .increases with the increase in the thickness of the pad

Molen) (6) conducted a study in the city of Tehran about measuring the performance of a) multi-stage cooling system. In the first stage, the water is cooled by night radiation, then the air is cooled in the second stage by indirect cooling and then by direct evaporative cooling. The results showed that the first stage of cooling increased The efficiency of indirect evaporative cooling, (Dia & Sumathy) (7) developed a mathematical model for the temperature of the water falling on the pad in direct evaporative cooling, where the study showed that there is an improvement in the cooling efficiency if the process of heat and mass transfer between the water falling on the pad is improved. (Wuer al) (8) conducted a study on the efficiency of evaporative cooling based on the method of thermal mass .equilibrium between air and the water layer in the pad

Where the study showed that the face velocity of the incoming air and the thickness of the ,filling is the key affecting the efficiency of direct evaporative cooling

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mohammed sohif bin mod)(9) conducted a practical study to measure the performance) of direct evaporative cooling in Malaysia using cellulose filling with a thickness of (5) cm, where the results of the study showed that the cooling efficiency increased between .%((63.5-77.3

This work aims to study the effect of changing the pad used from aspen wood fibers to cellulose paper on the humidification efficiency and air temperature differences

2-Theoretical analysis

The adiabatic process is that process that takes place on a fluid or air without providing or subtracting heat energy from it. Figure (1) shows a schematic diagram of an adiabatic saturation system, where the unsaturated air enters with dry temperature and moisture

content in case(1) and comes out of the system with a dry temperature, moisture content and heat content in case (2) and the system is completely isolated and there will be no heat exchange between the air and the outside environment, so the process is adiabatic - without adding or subtracting heat - where the feeding water is provided into the system to compensate the water which evaporates from it. when the surface of the water is large enough so that a sufficient amount of water evaporates in the air stream to ensure that the .air comes out in a state of saturation and the process is called adiabatic saturation
Confirmed conversions from laboratory results indicate that when such a system is equipped with a continuous air stream in a constant state of entry, the air outside in state .(2) will be saturated with adiabatic saturation at the same temperature
The temperature of the water in the equilibrium can be considered equal in all its parts during the process, regardless of the initial water temperature. This called the degree of adiabatic saturation

3-The working dynamics of the evaporative air cooler

The adiabatic saturation process takes place at a constant wet bulb temperature, and the final dry bulb temperature of the air drops to the wet bulb temperature if the air comes out of the process saturated, meaning that the sensible heat of the air turns into latent heat and the enthalpy remains almost constant during the process, and it may happen that the air comes out From the process it is not completely saturated, that is, the temperature of the dry bulb is reduced but not to the temperature of the wet bulb and the process is kept at a constant wet bulb temperature. Such a process is common in evaporative air coolers, air .scrubbers, spray cooling coils and some spray humidification equipment
The ability of air cooling in these devices lies in the ability to saturate the air and bring the temperature of the dry bulb as close as possible to the temperature of the wet bulb. Thus, the effectiveness of the evaporative cooler can be defined as follows'=(T1-T2) / ((T1-Tw1) …….(1
The maximum drop that can be obtained is the difference between the temperature of the dry and wet bulb of the incoming air, and most of the air coolers are manufactured to give a humidification efficiency of 80%, and the humidification effectiveness of the refrigerant is reduced in areas with high humidity such as coastal areas where the evaporative cooler .cannot provide an appropriate atmosphere for these areas
The effect of the filler used in the cooler affects the humidification efficiency, as the larger the surface area of the water sprayed on the filling, the greater the amount of evaporated water, and thus the greater the effectiveness of the evaporative cooler and vice versa. Fig-.ure (2) shows the process of evaporative cooling on the psychometric chart

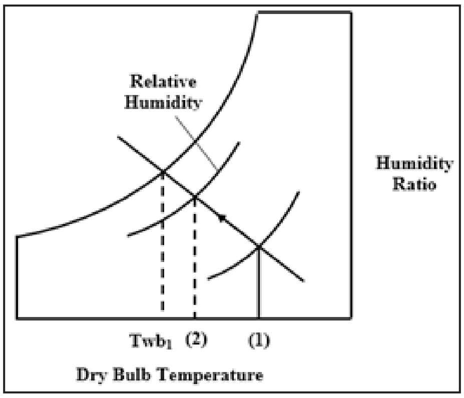

Figure (2) The evaporative cooling process on the psychometric chart

4-The practical part

Device description

An evaporative air cooler with dimensions (70 x 60 x 60) cm was used, powered by electrical energy generated from solar cells, and it consisted of the following parts as shown .(in Figure (3

1-Solar cell

A solar cell with dimensions (130 x 70) cm was used and it gives a direct current of (6.4) amperes and a voltage of (17) volts and an outputl power of (108) watts, as the photovoltaic cell was tilted at an angle of o45 degrees from the horizon in the city of Baghdad.

2-Battery

A battery with a voltage of (12) volts, 45 (ampere-hour) was used to store the electrical energy generated by the solar cell for the purpose of using it in periods when solar radiation is not available.

3-Electronic Regulator

An electronic regulator is used to regulate the charging of the battery by the solar cell and to ensure that the battery is not damaged.

4-The pump

A closed type water pump was used to circulate the water work on (12) DC and draw a current of 2.5 Amps

5-Fan

A (28) cm diameter axial fan was used and work on (12) V ,(4) amp

6-Control Panel

The panel consist of electronic thermometer , amper meter , operation switches

7-Cooler specifications

The dimension of cooler is (60x60x70) cm is made from galvanized steel gives 0.39 M3/s.

8-filling

Cellulose filling was used in the form of corrugated sheets, with a thickness of (10) cm

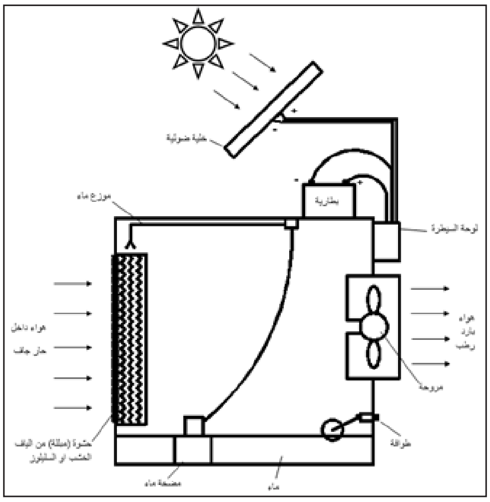

Figure 3: Solar-powered evaporative cooler

5-Results, discussion and conclusions

5-1Results

Figures (4, 5, 6) show the graphic relationship between the dry bulb temperature difference of the air passing through the cooler when using aspen wood and cellulose pads . Figures (7, 8, 9) show the relationship between humidifying efficiency with time when using the two types of pads

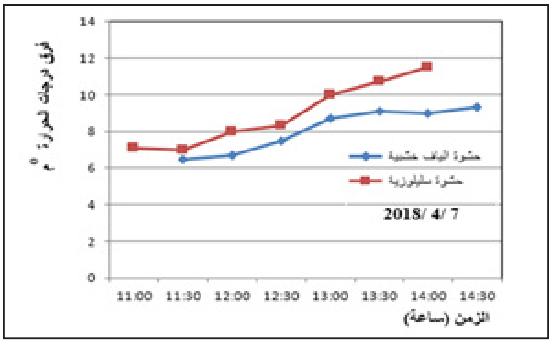

Figure (4) The graphic relationship between differences Dry air temperature and time

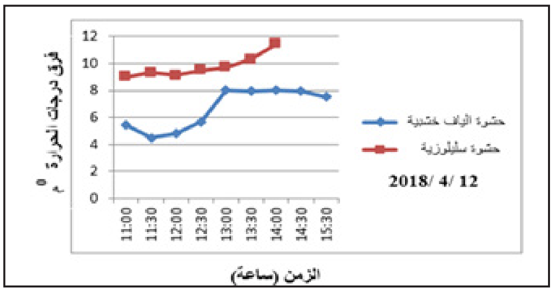

Figure (5): The graphic relationship between air dry temperature differences and time

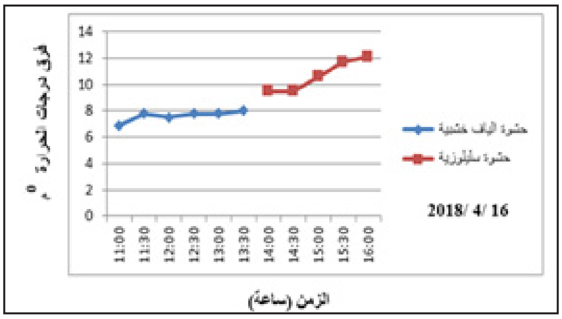

Figure (6): Graphical relationship between air-dry temperature differences and time

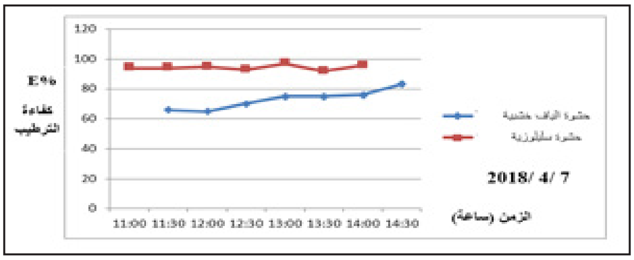

Figure 7: Graphical relationship between humidifying efficiency and time

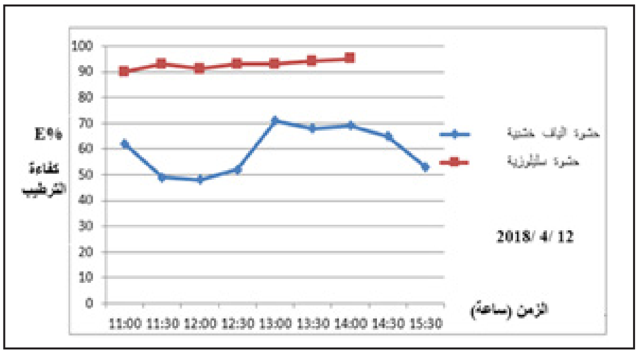

Figure 8: Graphical relationship between humidifying efficiency and time

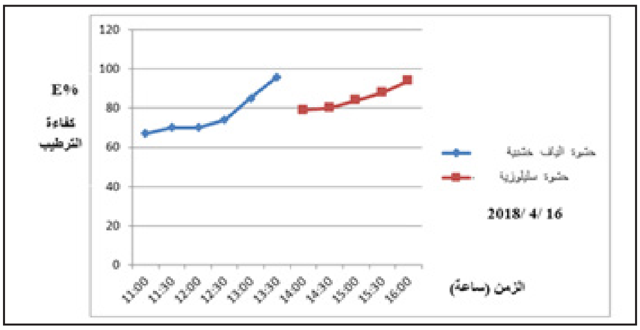

Figure 9: Graphical relationship between humidifying efficiency and time

Discussion

1-Figure (4)- shows the graphic relationship between the dry temperature difference of the air passing through the cooler in the case of using aspen wood and cellulose pads. It is evident from the figure that the increase in the dry temperature difference by (23.6)

% and the humidifying efficiency increased by (21.4) % when using the cellulose pad as .(shown in Figure (7

This is a result of the properties of the cellulose pad, which is characterized by spreading water over a large surface area and by absorbing it, and this consequently leads to an in- .crease in the amount of evaporated water and thus increases the cooling efficiency

2-Figure (5) shows the graphic relationship between the dry temperature difference of the air passing through the cooler in the two cases of using wood and cellulosic pads in different thermal conditions , where the amount of increase achieved in the dry temperature difference was 42.5%, and that The humidification efficiency increased by 58.4% as shown in Figure (8). This is due to the same reason mentioned above, in addition to the fact that the increase in the dry bulb temperature of the air entering the cooler also .contributed to this increase

3-Figure (6) - shows the graphic relationship between the dry temperature difference of the air passing through the cooler in the two cases of using wood and cellulosic pads in different thermal conditions , where the increase in the dry temperature difference was 51.2%, and that the efficiency of humidification increased by (20.3%) as shown in Figure (9) - for the same reason mentioned above

3-5Conclusions

From the above, we can conclude the following

1-The temperature differences of evaporative cooler that use cellulosic pad increase between (23.6-51.2)% compared to that using wood pad, and this range of increase also depends on the amount of dry temperature and relative humidity of the air entering the cooler

2-The humidification efficiency increases between (20.3-58.4)% with the use of cellulose pad instead of aspen wood pad

symbols

E: The humidification efficiency of the coolant M^0

Tin: dry temperature of incoming air C^0

Tout: dry temperature of the outside air C^0

Tw: the humid temperature of the incoming air C^0

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