Designation and fabrication a safe and noiseless evaporative cooler based on the suction, SENC which is compatible to use renewable energies such as wind and solar

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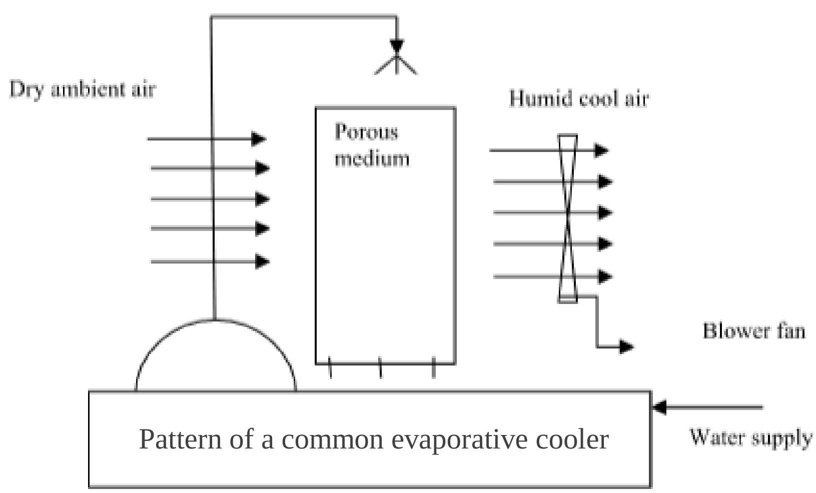
Abstract- Electricity and water are obviously used nearby each other in Common Evaporative Coolers, CEC. Therefore this point makes them as dangerous equipments for human daily life. Production of noise, visual pollution, high-risk of electric shock and high consumption of water and energy are some disadvantages of these evaporative cooling systems. In one hand contaminated water in the reservoir of CEC has to be directed into drain regularly. On the other hand with increasing population and development of human societies the number of CEC is increasing every year. The last point is the main reason of increasing the ambient humidity especially in a stagnant air where makes reduction the efficiency of evaporative coolers. Moreover, the heat produced by blower horsepower, belt, bearings and water pump weakens the performance and increasing water and energy consumption. In fact the work done by gravitational field on the water which is dripped continuously on the upper side of the pads, gives raise the temperature of water in the reservoir, so it cause more water consumption and produce more contamination. Even in an optimistic mode it is obvious that evaporative pads of CEC cannot be wet completely. The main objective idea of this paper is to introduce a new and different method for design and fabrication of an environmental friendly, high performance, Safe and Noiseless Evaporative Cooler, SNEC which is compatible to use renewable energies such as wind and solar for residential and industrial buildings.
Keywords- Evaporative Cooler- Recirculation Water pump - Noise pollution – Parabolic mirror- Renewable Energy

I. INTRODUCTION

Refrigerative systems have the advantage of consuming no water during their operation; however, they are using a lot of energy in comparison with evaporative ones. This point makes them as high cost instruments. Also, refrigerative air conditioning systems are in fact heat pumps that using greenhouse gases. These gases are harmful for ecosystem and cause to greenhouse phenomena and global warming. Therefore, at least from the view point of saving energy it seems to be economical and logical to use evaporative cooling systems rather than gas based refrigerating cooling ones. Of course, wide spread use of evaporative cooling systems (CEC) instead of common refrigerated cooling ones can also help delay adding expensive new power plants to the electric grid and the controversial transmission lines that often accompany them. Nowadays in order to increase the functioning of CEC, manufacturing companies provide instructions to guide users to exploit them in a correct manner. On the other hand in order to prevent contamination which disturbs the operations of CEC through defect water supply, its reservoir should be discharged at regular intervals of time. [Even though in recent years salinity of water is most easily measured using an Electrical Conductivity meter, EC. Special hand held salinity meters are available for this purpose, but conductivity sensors may be used to monitor the water quality within the reservoir and automatically control the amount of water that needs to be sent to drain] Thus in order to protect the correct functioning of CEC, its water supply must unaffected from water contamination. Moreover, production of water needs some energy sources. Thus, waste of water would be gives raised energy consumption, indirectly. That's the reason a number of utility companies in areas with hot, dry summers and substantial pollution growth have programs to promote the operation of CEC. Although common evaporative conditioners can provide years of trouble-free service to make cool, clean, fresh air at a relatively low energy cost and comfortable than refrigerant air conditioners, but I as the author of this article believe that they are still high consumption and dangerous instruments. [Due to the systematic functioning of CEC, density of solvable materials in the water is increased. Increasing the density of dissolved materials not only decreasing the functional quality of operation of water supply, but also it gives raise the conductivity of water in the reservoir. Certainly this point is the main reason that makes common evaporative coolers to be as dangerous devices in connection with electric shock. Many people die across the world due to electric shock by CEC yearly. Moreover, in an optimistic mode even in a normal situation the pads of CEC cannot be wetting completely. This point causes to weaken the cooling operation of CEC. Certainly, CEC with these serious problems would not be an ideal evaporative cooling system for residential and industrial use. Standard residential systems use evaporative media of shredded aspen fiber, typically 1 to 2 inches thick. Effectiveness is a measure of how closely the supply air temperature leaving the evaporative cooler approaches the outdoor wet-bulb temperature:

$$e = \frac{T_{DB} - T_{SAT}}{T_{DB} - T_{WB}}$$

The subscripts DB and WB refer to dry-bulb and wet-bulb respectively. SAT stand for the supply air temperature leaving the evaporative cooler system. Specific conditions of temperature, humidity and dust level inside an enclosed space are identifies by air conditioning systems[1] Evaporative cooling is based on a physical phenomenon in which evaporation of a liquid (usually water) into surrounding air cools an object or a liquid in contact with it. As the liquid turns into a gas, its phase changes and absorbs heat from gas. Technically, this is called the latent heat of evaporation. A common application of evaporative cooling are cooling towers, where a cloud of moisture evaporates absorbing heat from water drops, which are , therefore, forced to cool. By using air instead of water, the product of the procedure could be cold air, which can be applied in residential or commercial air conditioning. Water is an excellent coolant because it is plentiful, non-toxic, and evaporates easily in most climates. Evaporative cooling systems use the same laws of physics to cool machinery and buildings. Evaporative cooling is a very common form of cooling buildings because it is relatively inexpensive and requires less energy than many other forms of cooling. Unfortunately, evaporative cooling requires an abundant water source, and is most effective in climates with low humidity. In arid climates, homes and small business use direct evaporative cooling systems; often referred to as "swamp coolers" or "desert coolers". Manufacturing and industry often use evaporative cooling technically to remove excess heat from machines, compressors and other equipment. Evaporative coolers are air cooling devices which use simple evaporation of water into the air. These are most commonly found in homes and small businesses located in dry hot climates. They differ from refrigeration or absorption air conditioning, which use the vapor-compression or absorption refrigeration cycles (using Freon or other refrigerants in closed systems) to cool air re-circulated in the home. Evaporative coolers draw outside air across a wet pad or mesh into the home (while pushing an equal amount of air out of the home). As air passes through the wet mesh, the water in the mesh evaporates and cools the air. This process also humidifies the air before it enters the home, and can sometimes lead to too much humidity, creating a "swamp" feel and aroma in the home if improperly used. These coolers traditionally use potable water sources from local water utilities. The water consumption varies by size and type of equipment, quality of supply water, the local climate and temperature of water. A typical CEC will consume 80 L to 400 L of water per day if it is maintained properly. Figure1. Schematically show the basic parts of a CEC.



When air blows through a wet medium treated cellulose, fiberglass, or plastic some of the water is transferred to the air and its dry bulb temperature is lowered. The cooling effect depends on the temperature difference between dry and wet bulb temperatures1, the pathway and velocity of the air2, and the quality and condition of the medium 3 [2].

[1] The temperature of air measured with a thermometer whose sensing element is dry is known as dry bulb temperature. If thermometers sensing element is supported by a wet wick over which air is blown, the sensor is evaporative cooled to its wet bulb temperature. When the relative humidity is at%100, there is no difference between dry and wet bulb temperatures, but as the relative humidity of the air drops, so does the wet bulb temperature with respect to dry bulb temperature.

[2] Because lower air speed across wetted pads gives more exposure time to decrease temperature, thereby achieve more cooling and longevity of the pads is also increased.

CEC use a fan to pull outside air through porous media (pads) that are kept thoroughly wet by water that is dripped on them. The water is typically delivered via tubes from a small pump which draws from a reservoir below. The reservoir is replenished with tap water whose level is controlled by a float valve. CEC not only filters the air but also cools it. The resulting fresh, cool humidified air is blown into buildings where the pattern of flow is determined by the location and extent of openings in the conditioned envelope such as windows or special dedicated ducts. In dry climates, humidity is routinely quiet low and the differences between dry bulb and wet bulb temperatures are substantial4. For example in such these areas the relative humidity of %10 and dry bulb temperature 90F°, the wet bulb temperature is 58F° so that the difference between dry bulb and wet bulb temperatures is 32F° [3].Climates with such large depressions favor evaporative cooling techniques. The driving force of the evaporation is the humidity difference between the incoming air and the air- water interface, where the air could be considered saturated, consequently, the drier the supply air, the bigger the cooler capacity. Overall, the evaporative coolers designs are a lot easier on the grid than compressor- based cooling systems, because instead of peak demands of three to five kilowatts (KW) or more, typical demands for mid-size evaporative coolers are on the order of one kilowatt. Different types of evaporative coolers are known as indirect evaporative cooler takes advantage of evaporative cooling effects, but cools without raising indoor humidity. These cooling systems can use in various climate conditions as an environmentally clean and energy efficient system [4]. These combining CEC uses only electrical power to generate and distribute the cooled air via their fans and pumps. However CEC maintenance should be carried out by reputable maintenance service providers.

II. STRUCTURE OF SNEC

2.1 Cooling Unit (Fig.2), Cu

This part contains a typical metallic room of CEC without its spiral, water Pump, electric motor, belt and fan! The evaporative cellulose pads aren't installed directly on the metal chamber but they are installed on a cylinder (where I have named cylindrical pad holder, abbreviated by CPH is shown in Fig.1 CPH may be made from fiberglass, stainless steel or polymer material. SNEC hasn't common Recirculation Water Pump, RWP! Also it has not any Water Distribution Networks, WDN! Instead of these troublesome components CPH turning softly about the axis of symmetry. A few numbers of thin Half Cylindrical Containers, HCC are installed regularly on the CPH. These thin half cylindrical containers are playing the role of water supply. They are installed regularly around CPH so that they can contact water in the reservoir abrasively. The energy of rotational motion of CPH is provided by a low -voltage DC motor or by fresh air flowing into the building. In order to use a small part of kinetic energy of the blowing air to turn CPH, a butterfly is coupled with a spiral gearbox. A small part of kinetic energy of the air flow causes to rotation the butterfly. Therefore, the velocity of flow will be lowered a little and the pleasant cold air flow is established into the building. Air temperature would be reduced significantly in comparison with CEC. If we want to prevent the reduction of air flux, it is possible to use a low- power DC motor and a helical gearbox to turn CPH. [Although butterfly can turns the CPH, but its torque wouldn't be enough to turn RWP when the pads starting to wet. Butterfly′s torque (or low powered DC motor torque) must be amplified by a helical gearbox. In this situation CPH can be rotated softly by a very low angular velocity. In this case not only evaporative pads are wetted completely but also fine particles of water aren't produced. Unlike CEC, during the operation of system the force of gravity does not significant work on water to increase its temperature. (Since water is dripped over evaporative pads from a lower altitude) Then the temperature of water in reservoir would be lowered (in comparison to CEC) and consumption of water is also lowered. In SNEC, evaporative pads are wetted by salinity water without affecting the operational function of water supply. In CEC, due to dripped water on the pads three undesired situations would be taking placed. A) It causes the waste of energy. B) It produces fine particles of water. These particles damage the device and increase the risk of electric shock. C) Temperature of water in the reservoir is increased and as a result consumption of water would be increased. As a result, more water will be wasted. In areas where the salinity of water is high, use of CEC is accompanied another problem. As a result of water impurity, WDN is barred or RWP may be failed. Thus after a while CEC will needs to be repaired. However, such problems never occur in SNEC. Of course, in this project CU will be insight and installed in a shaded place, away from the sunlight. CU has not any risk of electrical shock and should be installed in an accessible place on the floor or patio. In using CEC a significant

[3] Media for evaporative coolers has to be efficient, which means that it must allow for us much cooling as temperature conditions allow while minimizing pressure drop, thereby saving fan power. Well designed media filters the air stream, but is also self cleaning, in that water dripping across it to the sump below performs a cleaning function. Finally, it should be durable and must be replaced at the end of its functional life time.

[4] This difference is called the depression of wet bulb below dry bulb.

portion of energy is wasted by bearings and high speed belt. Although belt and spiral fan decrease noises of CEC, but they cause to waste energy. Not only SNEC has not any noise but also its CPH moves with very low angular motion so that pads will be remain wet completely. Therefore increasing the wet surface of the pad leads to higher levels of temperature drop.

Fig.1 CPH which is used in the cooling unit

Fig.2 cooling unit chamber

2.2 Tower Unit

Tower unit, TU is part of the warm and humid air of the system which is set up on the highest position of the building preferably overlooking the services (bathroom, toilet and kitchen). All of the electrical accessories of the system are installed in TU. This unit from one side is linked into the indoor and on the other side is connected with outside of the building. Unlike CEC; instead of the cold air bellowed into building, the hot humid air is sucked by TU. Therefore in order to using SNEC correctly, all of the apertures and windows must be sealed to prevent leakage the warm air gets into the building. Humid cold air can only enter into the building through a predicted duct in the CU. TU does not need to be in a shaded place. It can operate under the sun light in order to use solar energy. In order to exploit the renewable energies such as wind and solar simultaneously (on the basis of convection) in evaporating cooling process, application of SNEC (which is based on suction of humidified warn air rather than blowing the cold air into the building) would be very suitable to match the system with a small non -integrated parabolic solar mirror [5] and wind chamber. One type of a non- integrated parabolic solar dish which is equipped with an advanced intelligent navigator system based on image processing of telescopic bar shadow [6] is shown by Fig.3. Various components such as electromotor, fan, and other electrical accessories are assembled in the tower unit far away from water source, out of the access of residents. There is another privilege of SNEC: Heat which is generated by electric motor cannot arrive into the building directly and weaken the evaporative cooling process. Thus the performance of the device is increased and users aren't encouraged to use the high speed function of the cooler. Thus, in turn, this issue reduces the consumption of water and energy. It is another reason which specifies that how SNEC helps us to save energy and water. Moreover suction of humid air from the building is done through the tower which is installed over the services. This point cancels the necessity of ventilator systems and this is another privilege of SNEC that helps us to save more energy. TU has a butterfly fan with a relatively large number of blades which is rotated gently and does not produce any noise. Moreover, SNEC can operate by electrical power and renewable energies simultaneously. The tower harnesses a suction generating chamber on its top in order to produce pressure difference. Wind is passing through the chamber and causes to drain the humid warm air from the building. Alignment of the chamber is adjusted automatically by a paddle as shown in Fig.4. Structure of the chamber has been designed such that the air velocity is amplified at the opening of the tower so it reduces the pressure due to Bernoulli's law. Fig.4 shows TU unit of the device which is taken at night.

Fig.4 Tower unit of an evaporative cooling system which is aligned in the wind direction of wind

Fig.3 A non -integrated parabolic mirror (solar dish) and its intelligent navigator system

III. DISCUSSION AND CONCLUSION

Usually our default may be that the effectiveness of an evaporative cooler system is independent of the number of the coolers which are used in a specific area. But it is clear that this assumption could not be considered as correct default especially in a stagnant warm air conditions which we sense that the response of an evaporative cooling system is not satisfactory. This is because of the fact that when N number of coolers is operating in an area, the dry bulb temperature, T_{DB} would be changed so it makes to change the effectiveness of $(N+1)$Th evaporating cooler. Therefore increasing the numbers of evaporative cooling systems in a large area not only cause to waste the water and energy but also cause reduction of performance of them. Thus the best way is that: we reduce the water and energy consumption in our evaporative cooling systems and design them compatible to use more renewable energies such as solar energy, wind and …. to prevent greenhouse and global warming of the earth. On the other hand, an important aspect that is often overlooked by home owners is the need to understand how a conditioner system works – not only how to use the controls provided, but also how best to use the system under various circumstances. For example, when outdoor temperatures are low but cooling is still required, systems can be operated in ventilation mode. When outdoor humidity levels are high the system should also operate in ventilation mode as the cooling ability of the system diminishes with rising outdoor humidity. It can be shown by a very simple calculation, how we can lower the consumption of energy and water by using SNEC instead of CEC. As an example we assume that there are at least 10000000 numbers of CEC in Iran which are being exploited for almost four months every year. We assume that the power which is needed for a cooler to be 700 W. Also in the optimistic mode we assume that at least forty percent of power is wasted (converted to heat and noises) through transmission lines, electro-motors and so on. Therefore the waste of power per one cooler would be 280 W. Then the total waste of power by total number of coolers is simply given by

$$P = 10000000 \times 280 = 2800000000 \text{ W.}$$

Optimistically, we also assume that each cooler to be turn off at night every day. Thus the total waste of energy by all of these evaporative coolers for four months of a year (only in Iran) is given as follows

$$E = 2.8 \times 10^9 \times 4 \times 31 \times 12 \times 3600 = 1.499904 \times 10^{16} \text{ j}$$

In connection with the function of operation of CEC, this large amount waste of energy in turn, indirectly causes to waste large amount of water!! Finally, only the equivalent mass of wasted water due to bad function of operation of CEC would be given as follows:

$$M = \frac{1.499904 \times 10^{16}}{2.26 \times 10^6} \cong 6.64 \times 10^9 \text{kg}$$

It is important to note that in a dry country such as Iran, the production of this amount of water also itself needs a substantial energy too. Therefore the bad operational function of CEC not only causes reduction the performance of device (which in turn, habitants in buildings have to use high speed function of their coolers) but also causes indirectly gives raise the consumption of energy and water. Therefore it is clear that using SNEC instead of CEC is alongside to the save energy and water. These in turn help us make prevent global warming issue. One sample of a fantastic type of evaporative cooling system, SNEC has been implemented in Kashan (Iran) and is used exclusively by the author.

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