REVIEW PAPER ON EVAPORATIVE COOLING SYSTEM

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ABSTRACT
Air-conditioning system is an essential role of ensuring occupants thermal comfort. Review the recent developments concerning evaporative cooling technologies that could potentially provide to sufficient cooling comfort, Then the reduce the environmental impact and lower energy consumption.[1] Evaporative cooling is an energy efficient and environmentally friendly air conditioning technology. Direct evaporative cooling systems technology which is involves adiabatic humidification and cooling of air with supplementary heat exchange facilities to the lower final air temperature and try to reduce the relative humidity. This concept is enhanced in all engineering fields due to its characteristics of zero pollution, energy efficiency, simplicity and good indoor air quality. This cooling effect has been used to the various scales use from small space cooling system to the large industrial applications.[2]

KEYWORDS: Evaporative cooling, humidification, applications etc.

INTRODUCTION

Evaporative cooling operates by utilizing natural phenomena where water and air are the working fluids. Evaporative cooling process is an commonly used for cooling towers, air washes, condensers, fluid cooling and also to the temperature in places where several heat sources are present. However it is also utilized for human thermal comfort. [3]

The air used for evaporating cooling is not too humid . Thus the faster rate of evaporation, grater is the cooling. The efficiency of an evaporative cooling depends on the humidity of the surrounding air. Very dry air can absorb a lot of moisture so greater cooling occurs. In the extreme case of air that is totally saturated with water, no evaporation can take place and no cooling occurs. When air passes wet surface then evaporating cooling occurs. Generally, an evaporative cooling structure is made of a porous material that is fed with water. Hot dry air is drawn over the material. The water evaporates into the air raising its humidity and at the same time reducing the temperature of air. [4].

CONCEPT OF EVAPORATIVE COOLING SYSTEM

The evaporative cooling (EC) technology is based on heat and mass transfer between air and cooling water.[5]

Evaporative coolers could be classified into:

1) Direct evaporative coolers, in which the working fluids (water and air) are in direct contact.
2) Indirect evaporative coolers, where a surface/plate separates between the working fluids.
3) Combined system of direct and indirect evaporative coolers with other cooling cycles. Fig. 1 illustrates a general classification of main types of evaporative cooling systems.[1]

Direct evaporative cooling (DEC) is based on mechanical and thermal contact between air and water, while indirect evaporative cooling (IEC) is based on heat and mass transfer between two streams of air, separated by a heat surface with a dry side where only air is cooling and a wet side where both air and water are cooling. Both DEC and IEC are characterized by very high energy efficiency but it is also by significant water consumption rates.[5]

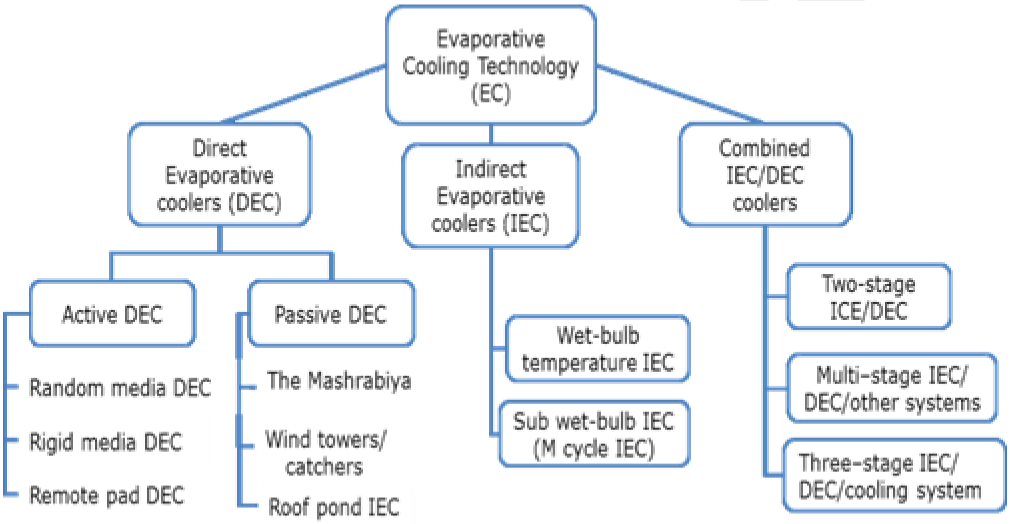

Fig.1. Classification of evaporative cooling systems [1]

1) DIRECT EVAPORATIVE COOLING SYSTEM:

The working principle scheme of the DEC equipment and a simplified flow scheme are presented in figure 2. The warm inlet air (1) enters in a pad which is sprayed with water at the wet bulb (WB) temperature of the inlet air. The greater the difference between the two temperatures, greater the evaporative cooling effect. Evaporative coolers provide cool air by forcing hot dry air over a wetted pad. The heat is transferred by the air stream as sensible heat and is absorbed by the water as latent heat. Corresponding to the value of latent heat, a part of the water is evaporated being embedded by diffusion into the flowing air, increasing the moisture content of this air. The temperature of the outlet air (2) decreases due to the sensible heat transferred by the air, but the enthalpy of the outlet air will be the same with the enthalpy of inlet air as effect of the latent heat recovered into the air as moisture. The working process of the DEC equipment is presented in the psychometric chart in figure 3.

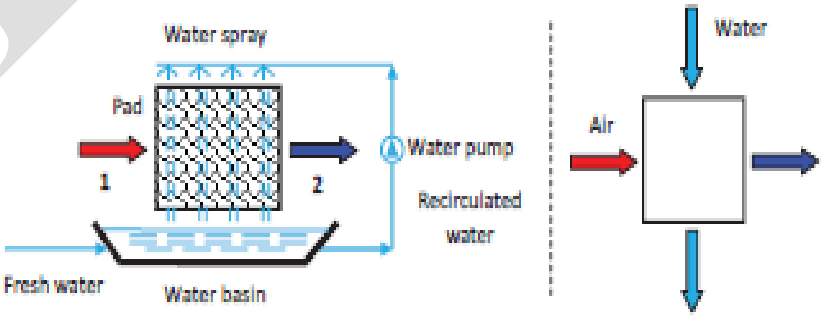

Fig. 2. Working principle scheme and simplified flow scheme of the DEC

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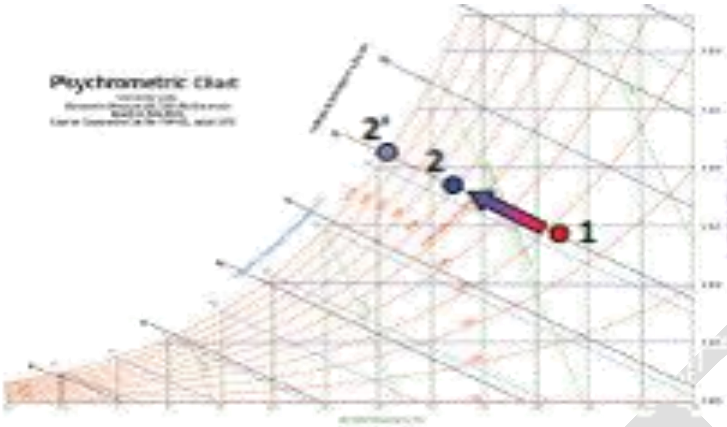

Fig. 3. The working process of the DEC

The working process (1-2) :- constant enthalpy as it can be observed on the chart. At limit, the cooling process could be continue until the state of saturation (2').

1) The main advantage of DEC is represented by the very simple construction of the equipment.
2) The main disadvantage of the DEC is represented by the increasing of the air moisture content which may be undesirable for certain applications.[5]

2) INDIRECT EVAPORATIVE COOLING SYSTEM:

The IEC working conditions were divided in: primary and secondary air working conditions; parameters of water; flow regimes; pressure drops and geometry. [6]

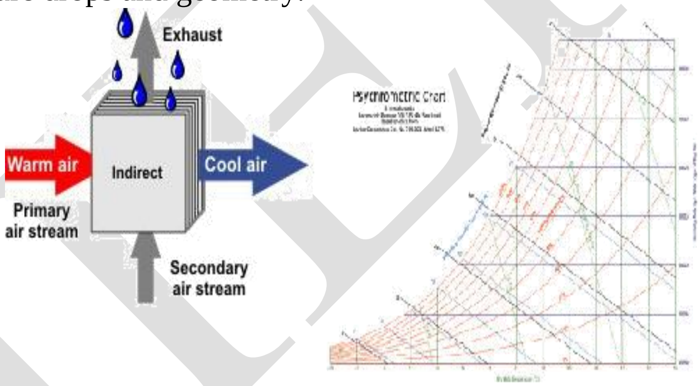

Fig. 4. Working principle scheme & the working process of the IEC in the Psychometric chart

The working process of the primary air (1-2) is realized at constant moisture content and the working process of the secondary air (3-4) is realized at constant enthalpy as it can be observed on the psychometric chart. At limit, the cooling process of the primary air could continue until the Wet bulb temperature of the secondary air at the inlet.

The advantage of the IEC is that primary air is cooled without modifying its moisture content.

The disadvantage of the IEC is that the cooling process of the primary air is limited by the Wet bulb temperature of the secondary air at the inlet. Because of this limitation, this type of equipment is also named at wet bulb IEC. 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. The systems are:-

1) Indirect evaporative cooling system both the dry bulb and wet bulb temperatures are reduced.
2) Indirect evaporative coolers do not add humidity to the air, but cost more than direct cooler sand operate at a lower efficiency.[5]

OBJECTIVE

The main aims of evaporative cooling system are:
1) Improving energy performance of chiller, condenser, cooling tower.
2) Increasing the COP of refrigeration system.
3) Increasing the thermal effectiveness.

APPLICATION OF EVAPORATIVE COOLING SYSTEM

A) EVAPORATIVE COOLING SYSTEM USED IN CONDENSER:

- **LAYOUT OF THE SYSTEM:**

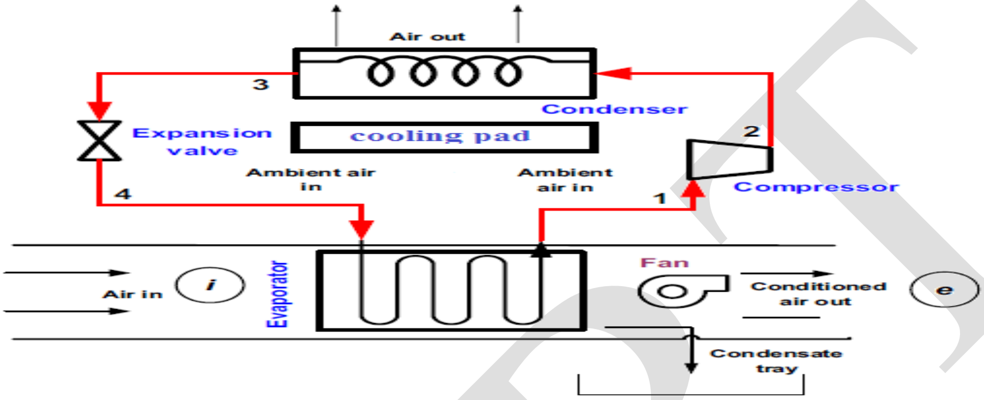

Fig.5. Basic components layout of evaporative cooling system.

- **WORKING OF SYSTEM:**

Adiabatic air-cooling System concept is based on intermittently and efficiently evaporating water on a large cooling pad area in front of the heat rejection surface of Condensers and Dry Coolers. Water spray provides an adiabatic cooling effect of till 20°C-25°C for the incoming air stream and it can be initiated via an ambient sensor or alternatively by external control override. As soon as settings exceed, a pre-set level controller initiates water spray in order to make air temperature lower during high ambient periods.

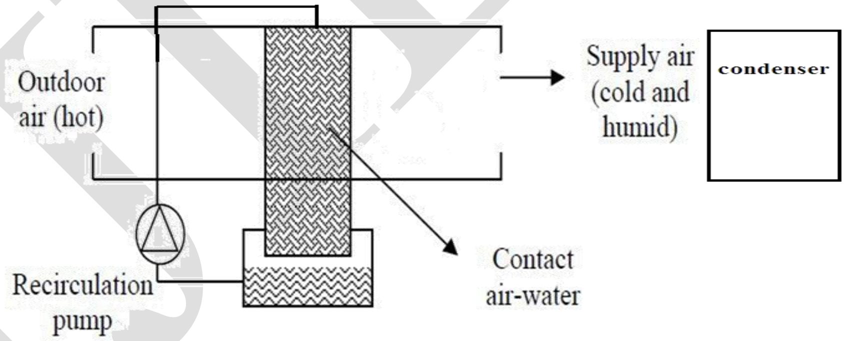

Fig.6. Actual working diagram of evaporative cooling system.

Evaporative cooling can be achieved in different ways, but most systems include the following components.
• A water supply system that intermittently sprays water into the air flowing onto the cooling pad. You can use a mains water supply, but if the water pressure is low you may need a pump.
• A coarse fabric cooling pad fitted across the air flow onto the condenser. The water is sprayed onto this to keep it wet. The surface area of the cooling pad needs to be as large as possible to make the system effective in lowering the air temperature.
• A control system to make sure that water is only sprayed when needed and in the correct quantity. Water can be controlled either by a sensor measuring the temperature of the incoming air, or the refrigeration system condensing pressure. As an adiabatic cooling system is designed to be a total loss system there should be little risk of Legionella contamination. Unlike wet cooling towers or evaporative condensers, all

the water sprayed is soaked cooling pad, withre-circulation of excess water. To prevent corrosion problems, you should fit non-metallicsprays and make sure that water is not sprayed directly onto the condenser coil. If you are using cooling pad, these should also be non-metallic and be fitted externally so that they can be replaced without removing refrigerant from the system.

- **DESIGN METHODOLOGY**

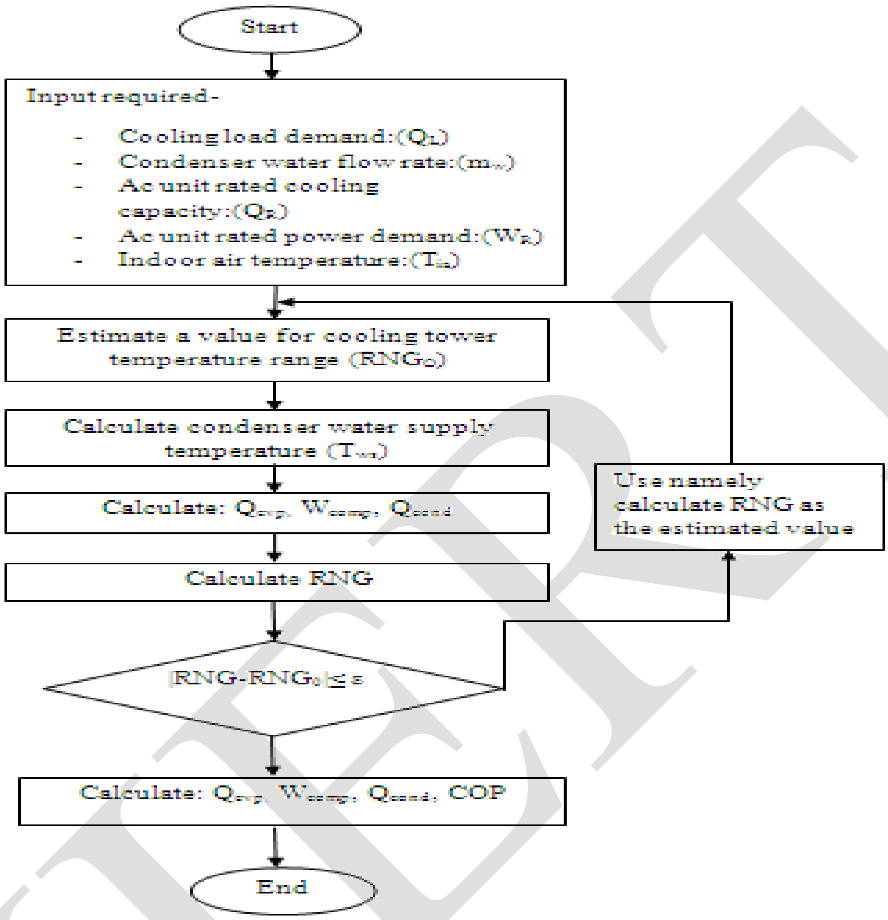

Fig.7. Methodology of evaporative cooling systems [6]

ADVANTAGE

1. RUNNING COST:

Lower condensing temperature provides reliable operation and lower annual electricity running costs.

2. REDUCED WATER CONSUMPTION:

Water is used whenever it is required at significantly reduced quantities.

3. FLEXIBLE SYSTEM:

Sectional panel and coil clip design suits with any brand and model of mini-splits, air cooled chillers, rooftop units, air cooled condensers and dry coolers on the market.

4. LOWER MAINTENANCE COST:

Reduced condenser pressure leads to reduced discharge temperature which extends the compressor reliability and life.

5. QUICK RESPONSE:

Large mesh surface area provides efficient adiabatic cooling surface with minimum air flow reduction, hence, water evaporates very rapidly to cool the incoming air.

6. ELIMINATES HEALTH RISKS:

It uses water directly without any water reservoir; hence, the health risks associated with a still water reservoir are completely eliminated.

7. GREEN SOLUTION:

Reduced energy consumption. Hence less indirect CO_2 emission.

CONCLUSION

Using water for evaporation as a mean of decreasing air temperature is considerably the most environmentally friendly and effective cooling system.We have to observe the condenser discharge pressure we conclude that the compressor work would be reduced. Hence the COP will be increases and decreased the power consumption. Saving the 20- 25% energy.

In this way adiabatic pre-air cooling system is beneficial for energy consumption.

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