Adiabatic cooling and its future aspects in commercial building and others: A review

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Abstract

In warm conditions, to maintain cool atmospheric temperature air conditioning plays a crucial role. To control ventilation and cooling procedure in buildings commercial cooling systems are very essential, but they consume more power and are responsible for the emission of CO_2. Energy-efficient air conditioning frameworks can reduce energy consumption and CO_2 emissions. The aim of this paper is to find out various technologies involving evaporative cooling and energy management in smart cities. Evaporative cooling has gained researchers' attention in recent years and is very energy efficient and environmentally friendly in the air conditioning industry. However, this technology consists a lot of challenges. Evaporative cooling technologies are energy-efficient and cost-effective. Energy-efficient state of art technology has become the research focus around the world, especially for the power grid. Insufficient evaporation from inadequate and non-homogenous pre-cooling pad water distribution lowers cooling performance.

Keywords. Adiabatic cooling, chiller HVAC systems, Building cooling requirements. DEC, GHEs.

1. INTRODUCTION

In the modern world, energy management is an important aspect of the research field to reduce global warming. Several researchers have worked to find out the best possible way to reduce greenhouse gases emission [1, 2]. Due to greenhouse gas emissions, the temperature at the earth's surface has increased sharply. One of the main reasons for global warming is the conventional Air Conditioning System, due to its large consumption of electricity [3, 4]. Several kinds of research have been made to partially replace the conventional air conditioning system to reduce the consumption of electricity and in turn, reduce global warming and the use of refrigerants which affects the environment [5]. This review paper focuses on the use of adiabatic cooling in various fields and energy management in smart cities. Evaporative cooling, sometimes known as adiabatic cooling, cools the air by

evaporating water [6, 7]. Water evaporates as a stream of air during evaporative cooling. This transformation requires heat from the air, which cools the air [8]. The amount of water that can be evaporated is directly proportional to the amount of sensible heat that can be absorbed [9,10]. This evaporative cooling method can be implemented in smart cities with new approaches and modern technologies [11, 12]. In DEC (Direct evaporative cooling) technique, the air is in contact with evaporated water, increasing its water content [13]. And in IEC (Indirect Evaporative Cooling) technique, evaporation takes place inside a heat exchanger, and the moisture content of the cold air remains completely unchanged [14]. DEC can only be used in places where the relative humidity content is very low [15]. This is due to the fact that high evaporation rates might cause an increase in relative humidity, which can lead to discomfort [16].

2. METHODOLOGY

More than 100 papers have been studied from Scopus, Science Direct, Google Scholar, and Web of Science in relevance to the paper. And a summary sheet of the selected research papers is developed to introduce various methodologies to achieve desired cooling effect from the evaporative cooling system.

3. REVIEW OUTCOMES

Author's name and year	**Major problems discussed**	**Solutions suggested by the researcher in paper**
Ana Tejero-Gonzalez et al. (2021) [17]	Design of DEC pads optimally to increase the performance of cooling.	The optimally designed DEC pads have maximum water-to-air surface contact which favours air saturation, but very less resistance to airflow. A rigid media that achieves total humidification through a high water-to-air contact surface is simple to install, disassemble, clean, and maintain. The recirculated water temperature is considered to be close to air Wet Bulb Temperature, in adiabatic systems, but experimental results can be higher or lower. In adiabatic systems, measuring water temperature helps in understanding the air conditions at the system's outlet and the saturation efficacy.
Anatolijs Borodinecs et	The major problem discussed in this paper is	Nozzles have been designed to spray fluid on the designed

al. (2022) [18]	the insufficient evaporation caused due to the substandard and non-homogeneous distribution of water over the pre-cooling pad.	additional metal mesh cooling pad to improve cooling efficiency. Results show that it increases the mass transfer coefficient by 15–25%, An increment of 20% to 40% of the heat transfer coefficient and an increment of 30% to 40% of the atomization efficiency occurs. The installation of metal pad mesh results in uniform distribution of water.
Sachin Sunil Mothiravally et al. (2021) [19]	Pre-cooled air in the commercial prevailing cooling system can improve its cooling efficiency.	The result analysis shows that implementing the adiabatic cooling pad in commercial HVAC units saves energy by 20% with a good investment return.
G¨okhan Yıldı.(2022) [20]	Energy consumption worldwide is due to the energy consumed by air conditioning systems in residential and industrial buildings. Evaporative cooling systems are advantageous since it is economical; It has zero pollution, and is easy to maintain, thus reducing the consumption of energy in buildings.	With four different evaporative cooling conditions exergy and cooling efficiency have been analysed. The 3rd case has the highest exergy efficiency at 20.83. In the 2nd case, the highest loss in specific exergy was found to be 100.51 J/kg and in other cases, the loss was calculated as 74J/kg, 81J/kg, and 74J/kg respectively, During the analysis same conditions it was found that values of sustainability match with exergy efficiency. Exergy and cooling efficiency rise at high airspeed under negative pressure but decrease under positive pressure.
Eloy Velasco-Gómez et al. (2020) [21]	Conventional cooling pads are less durable and cooling efficiency degrades with time.	The present work focuses on the design of an alternative evaporative cooling pad using cotton fabric. The cotton fabric used in this particular design performs better. When compared to other materials, its design allows for the maximum wetted surface with the minimal amount of pressure drop.
G. Cortella et al. (2019) [22]	During warm and hot climatic conditions efficiency and operation	Warm and hot climate is responsible for change of pressure of CO_2 and a pre cooled air in

	performance of Carbon di oxide is affected.	condenser can reduced pressure of CO_2 and can improve its efficiency. With the help of subcooling method using evaporative systems in the gas cooler is a best way to minimize coming air's temperature. By this way we can reduce the pressure of CO_2 and it will help to enhance the plants efficiency The implementation of adiabatic cooling results in reduction of 10% in the energy usage.
Ghassem Heidarinejad et al. (2010) [23]	Global warming and depletion of fossil fuels results in climatic change. Artificial energy resources are one of the main causes of global warming and therefore it is very important to replace it with natural resources. Ground cooling is a type of passive cooling technique which is very economical and can be used as pre-cooler in conventional system.	Geothermal energy-based condensers are a fast-growing renewable energy-based condensers. Earth's ground can be used to reject heat and can get subcooled situations of the refrigerant. It is also helpful to get the warmth in winter season with reversed cycle also it can be used in hybrid mode to improve the efficiency of the cooling system.
A Anarbaev et al. (2020) [24]	Wet mats used in evaporative cooling increases the quality as well as its cost which in turn increases the price of cutting flowers during summer season.	Evaporative water cooler has an efficiency(thermal) of 79%. During evaporative cooling operation it was found in the experiment that temperature rises up to 28 and the humidity is 71% in a green house.
Azzeddine Laknizi et al. (2019) [25]	Evaporative cooling pads are quite expensive with less life cycle. Scaling and Rusting is a major problem while using conventional cooling pads. For attractive pads there is need of low-cost material pad.	Evaporative cooling pad made up of tubular pottery rods has been designed and tested. The research output is as follows: The temperature reduces by 10 and the relative humidity increases by 5% The saturation efficiency is found to be between 49% and 66% approximately.
Sarvesh	Approximately 36% of the	The direct and indirect evaporative

Kashyap et al. (2021) [26]	entire population of the world lives in areas where the daily mean temperature exceeds 25 . Increased standards of living, constantly growing population, and regular heat waves have quadrupled energy use for cooling. Currently, there has been a rapid increase in the need for efficient cooling methods.	coolers are clubbed into a single unit. The cooling system (dual mode) comprises of regenerative type heat exchangers. It also consists of extra arrangement (vanes) to stop dry channel flow during direct operations. The greater the ratio of extraction in regenerative mode results in increased effectiveness of the system. But the cooling capacity reduces. The Coefficient of Performance reduces to 53% and the effectiveness increases by 10% during the analysis.
Ahmed Y. Taha Al-Zubaydi et al. (2019) [27]	The WBT efficiency measures Indirect evaporative cooling's (IEC) performance. As a result, the system is restricted to the secondary air's WBT. Therefore, the efficiency of IEC is low and not suitable for large buildings when the secondary air's humidity is high.	In this work, an innovative spraying arrangement was suggested. The system under investigation is an IEC with nozzles internally placed to spray water into the wet channel. With the water spray on cooling pad can increase cooling load by 12.5%.

4. RESULT OF REVIEW

This paper examines the Evaporative cooling process that has been under use in the past and it is very popular cooling method. Few researches have been made regarding the improvement of the effectiveness and how to use it in commercial and residential building as well as other apartments with less energy consumption. The techniques utilized in the adiabatic cooling process are also discussed. The study also discovered that the adiabatic cooler/chiller would operate at low power consumption with higher efficiency and comfort cooling without using any harmful refrigerants. After the review of various research papers, it is suggested that adiabatic cooling systems are good option to achieve proper cooling and ventilation with better energy management for a smart city or other commercial apartments. The improvement of cooling pads has also been discussed as it is a very important part in evaporative cooling. Methods of spraying water by various methods into the cooling pads and using clay to build tubular pads to increase its efficiency has also been a topic of discussion for researchers.

5. CONCLUSION

The review paper gives a detailed study on how we can reduce emissions of greenhouse gasses and minimize global warming by using evaporative cooling instead of commercial refrigerants for air conditioning. It also provides a cheap process of air conditioning. Energy management being as the top priority for researchers in modern world use of evaporative cooling can be a game changing method in HVAC sector as it doesn't consume or consumes very less amount of electric current thus reducing energy consumption. After the review it has been found that installing higher-efficiency based adiabatic chiller and coolers is the best way to achieve a comfort cooling in buildings apart from traditional air conditioning systems.

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