A Review on Earthen Tube Air Cooling System for Space Cooling Application

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ABSTRACT

A ground-coupled heat exchanger is an underground heat exchanger that can capture heat from or dissipate heat to the ground is known as the earthen tube. Thus, the earthen tube has prospect use in space cooling application and also the short-term preservation of vegetables and fruits soon after harvest. The earthen tube is often viable and economical alternative or supplement to conventional central heating or air conditioning systems since there are no compressors, chemical or burners, and only blowers are required to move the air. In this water is linked to the cooler at the top, thus keeping the chamber cooled. The result of the transient performance of the cooler reveals a decrease in temperature in the building or storage chamber. The different types of evaporative cooler designs under review include: earthen tube, cabinet, static, and charcoal cooling chambers. The literature regarding porous evaporative air cooler and the earthen tube for the cooling of the building is reviewed in this paper.

Key Words: Earthen tube, Evaporations, Pours Material, Space cooling.

1. INTRODUCTION

According to the latest estimates, the global energy consumption in 2020 would to more than twice of the recent level. Such a consumption of energy increase environment pollution and shortage of energy. About one third of India energy consumption is being used for space cooling and heating application. At present the energy need is fulfilled mainly by fossil fuel based energy, which can lead to earnest environmental issues such as pollution. They are non-renewable sources of energy as they are derived from pre-historic fossils and won't be available once they are plenarily used. The sources are limited and they are depleting at a faster rate. However the contribution from renewable energy are limited at present. It is necessary to find urgent alternative sources to replace conventional fuel or at least minimize its widespread consumptions and the consequent impact on the environment.[3]

In order to meet building air conditioning requirement either passive systems or renewable energy should be used. Passive cooling/heating system utilizes available on-site energy from the natural environment rather than mechanical systems to dissipate/gain heat. An earth air tunnel heat exchanger uses earth as a heat sink and heat source to cater heating and cooling loads thereby significantly reducing the requirement of a conventional heating/cooling system. Air flows through the pipes buried inside the soil and transfer heat to and from the soil thus providing cooling and heating inside the building spaces.[3]

Developing countries like India Africa and South Asia use eco-friendly and cheap cooling system by using cheap materials and consumption of less amount of electrical energy for cooling is required. This technology is to use easily available cheap clay as raw materials. 2-3]

With the improvement of urbanization, substantially more heat is produced by building, individuals or machinery and put into urban condition, in this way the impact of urban heat island develops and urban heat island force shows a developing pattern as of late. The air conditioning system of mechanical vapor compression are used to meet the increasing in living standards. Thus it proves to be an unsustainable factor that leads to urban pollution at the greater risk of increased morbidity and mortality. Numerous elective cooling techniques for keeping up thermal comfort in building have been created. In dry and hot region the uninvolved evaporative cooling method centers a warmth pick up control and heat dissipation in a working so as to enhance the indoor thermal comfort with low or no energy consumption. [4-5].

2. LITERATURE REVIEW

Sekher K. A et. al (2017) worked on project to preserve the food items like fruits and vegetables with the help of an unconventional refrigeration technique, here they select evaporative cooling for the preservation of food items. The whole consists of a specially made clay box (like Mansukhbhai Prajapati’s Mitti cool refrigerator with some

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difference), submerged water pump, Exhaust fan, Solar panel, Battery, Solar Inverter. Refrigeration by evaporative cooling has proved to be a successful alternative in providing inexpensive and environment friendly way to preserve the food. [5]

Brijendra Singh Bhaskar et.al. (2017) conducted research on heat transfer through the porous material, mostly metal foam heat exchanger. The forced convection has been reviewed extensively and at low fluid velocities the effectiveness is high and vice versa. The best performance was exhibited by aluminum foam having a feature (porosity ε = 30%, velocity u = 0.2 m/s)[6] when the effectiveness of the heat exchangers are compared at velocity u = 0.5–7 m/s fluid velocity,

Anuj Mathur et. al (2017) studied thermal performance of straight and spiral earth air tunnel heat exchanger (EATHE) system and revealed that the thermal performance of a spiral EATHE system has lesser aspect ratio (1.06) when compared with the straight EATHE system. [7]

Sandip Kale et. al (2017) studied the earth tube heat exchanger as an emerging techniques which reduce the overall consumption of energy in a building by reducing the cooling load of buildings in the summer season. To study the performance in cooling mode single pass Earth-Tube Heat Exchanger (ETHE) was installed. ETHE cools the ambient air in March by as much as 15 °C. Maximum COP obtained was 2.5. Basic theories of air conditioning were used to determine the selection parameters for a blower. [8]

Nabil A.S. Elminshawy et. al (2017) developed air passive cooling system which consists of an earth-air pipe heat exchanger. The results was in the range between 8 and 24 °C across the earth-air pipe heat exchanger and the system effectiveness varied between 0.3 and 0.7 depending on the operating conditions and soil. [9]

Niyukti Sogale et. al (2017) performed research on the web, they came across many papers from which they found that energy can be used for preconditioning the air. Air is drawn from a long underground metal tube. As air peregrinates through the pipe, it gives up or receives some of its heat to/from the surrounding soil and enters the room as conditioned air during the cooling or heating period. [10]

Rafal Andrzejczyk et. al (2017) conducted the experimental study on the impact of geometrical parameters of the coil. It is possible to increment the efficiency of the heat exchanger shell type coil with baffle inserts. The baffle and inlet configuration has a high impact on results. Correlation gives a copacetic compliance with experimental results. It should be noted that the correlation can be applied for all of the presented heat exchanger configurations. [11]

X. Cui et. al (2017) developed a mathematical model for the cooling coil unit and validated against experimental data. Experimental results clearly demonstrated the capability of the proposed air-purification process to maintain an acceptable indoor air quality. [12]

Guilian Leroux et. al (2015) developed numerical model predicated on the heat and mass transfer balances and compared with experimental results, exhibiting precise results in terms of energy balance and prediction of water-cooling.[13]

Ashish Kumar Chaturvedi et. al (2015) directed a trial contemplate on earth air heat exchanger framework in parallel association in the late spring atmosphere and warming with air in winter atmosphere in LNCT Energy Park Raisen Road Bhopal, M.P. [14]

Sanjeev Jakhar et. al (2015) completed plan and reenactment in transient examination apparatus TRNSYS (v17.0) by fluctuating its working parameters which included mass flow rate, length, pipe materials and breadth of the covered pipe. Further, the Earth Water Heat Exchanger (EWHE) execution is observed to diminish with an expansion in the mass flow rate from 0.008 kg/s to 0.05 kg/s. [15]

Prabodh Sai Dutt R et. al (2015) investigated reviewed on a few of the recent developmental designs towards refrigeration, both for agricultural produce and domestic usage by evaporative cooling. [16]

Harish. H. G et. al (2014) conducted an experimental analysis of a clay pot refrigerator for free and forced convection. Results obtained from experimental analysis shows that pot refrigerator is subjected to free convection and highest when it is subjected to forced convection. [17]

Keng Wai Chan et. al (2012) demonstrated that soil is a promising cooling medium in the arid region, yet it has failed to meet expectations in hot-moist tropical nations. The soil temperatures at the profundity of 0.25 m and 1.00 m underneath the surface secured by wood chips are the most reduced contrasted with different examples. [18]

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Ndukwu Macmanus Chinenye (2011) developed evaporative cooler with clay and other locally available materials. The performance of cooler was evaluated in terms of temperature drop, evaporative efficiency and cooling capacity. The result showed that the evaporative cooler can reduce the quotidian maximum ambient temperature from 320C - 400C to 24 – 290C i.e. a temperature reduction of up to 100C and increment the relative dampness of incoming air from 40.3% to 92% for the storage chamber. [19]

Poonia M.P. et. al (2011) exhibited paper on evaporative cooler which produces effective cooling by combining a characteristic procedure – she recommended that water evaporation with a simple, reliable air-moving framework, evaporative cooling is most efficient and powerful methods for refrigeration and air cooling since its inception especially in the territories where climatic conditions are hot and dry.[20]

Vikas Bansal et. al (2010) created transient and implicit model predicated on computational fluid dynamics to anticipate the thermal performance and cooling capacity of Earth–Air–Pipe Heat Exchanger Systems (EPAHE) and from the analysis it was shown that the performance of the EPAHE system is immune to the material of the buried pipe, consequently a cheaper material pipe can be utilized for making the pipe. [21]

Isaac F. Odesola et. al (2009) reviewed the types of evaporative cooler designs which include: pot-in-pot, cabinet, static, and charcoal cooling chambers. The result of the evaporative cooler has a prospect for use of short term preservation of vegetables and fruits soon after harvest. [22].

3. DISCUSSION

The review reveals earthen tube heat exchanger systems were either constructed for research purposes or commercial use. From the study of different heat transfer systems through pours material, it is found that there is an application of two different heat transfer augmentation techniques to improve the performance of an air-cooled heat exchanger. However, market available, and general earthen tube techniques are used but each of it having some limitations along with its uniqueness too. All space cooling techniques have one common goal that is to improve the efficiency of eco-friendly air conditioning system.

The current earthen tube design methodology has some serious issues which are mentioned as follows, in this

•Size of earthen tube,

•Area required for installation of whole system, and

•Air quality have become important issues for all kind of passive cooling systems including earthen tube systems.

•Earthen tube system with utility, it is necessary that the system should meet the controlled percentage of humidity and the air supply requirement for a human comfort in the building.

Most of the earthen tube related published articles are based on relative humidity, air temperature and surface area of tube and air movement.

Human comfort is gaining importance in the recent decades. In order to meet building air conditioning requirement either passive or renewable energy should be used. Passive cooling or heating system utilizes available site energy from the natural environment rather than mechanical system to waste or gain heat. Most of the cooling systems mentioned in published articles are based on earthen tube evaporative from pours tanks and the few articles on concentrating photovoltaic cooling. The porous material prepared from clay for cooling of building by the elimination of heat through evaporative cooling.

4. CONCLUSION

The earthen tube system requires more space for installation, if properly designed, it can be feasible and economical option to replace conventional air-conditioning systems as there is no need of compressors, burners, or chemicals and only blowers are required to move the air. The earthen tube is promising and effective technology for space conditioning of buildings.

Also there is a scope to make different arrangements for positioning of clay tube in order to increase the contact of air with wetted surface to improve the performance of system.

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