International Journal of Heat and Technology
Vol. 40, No. 3, June, 2022, pp. 773-780
Journal homepage: http://iieta.org/journals/ijht

Performance Enhancement of a Ventilation System in Hot and Dry Climate Using Air-PCM Heat Exchanger

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https://doi.org/10.18280/ijht.400316

Received: 1 May 2022
Accepted: 12 June 2022

Keywords:
free ventilation, hot-dry climate, PCMs, thermal energy storage

ABSTRACT

The building projects' power consumption and CO_2 emissions are 40% and 33%, respectively. It is a viable strategy to use phase change material in energy storage to provide free cooling. There are few studies on free cooling in hot climates, so the proposed system uses paraffin as a thermal storage material for free cooling and ventilation. The project contains a cooling tower, a horizontal slab heat exchanger between air and phase change material, and an indirect compact heat exchanger between air and water. The energy equation is computed using Engineering Equation Solver software to assess the overall system perform properly. The model investigated the parameters that affect the system's performance under various climate conditions. The system has improved indoor air quality by providing ventilation and extending the period of thermal comfort. The system's performance is determined by the cooling tower's performance and the Air to PCM and Air to water heat exchangers. The Air to PCM heat exchanger reduces supply temperature by 2°C with a slight pressure drop < 20Pa and does not affect system power consumption.

1. INTRODUCTION

Increasing energy consumption, concerns about climate change, and even reducing limited fossil fuel resources are all significant issues. Renewable energy is an alternative to fossil fuel energy. Using it in building projects is critical due to its high energy consumption [1]. Renewable energy is difficult to implement since it is inherently intermittent, inefficient, and unreliable [2]. Energy demand rises in lockstep with energy production, although there is a disparity between the two. When considerable stress is put on a power plant in a short period, it may decrease its lifespan and diminish system efficiency. Energy consumption must be shifted from peak to peak off power periods to rectify the mismatch between energy generation and consumption. In Iraq-Erbil, building energy usage was 62% in 2015 [3], compared to 40% globally [4]. Energy Storage is a great way to manage and bridge the gap between demand and supply energy. Buildings are an ideal location for Thermal Energy Storage (TES) implementation due to their high energy usage. TES can be used as an active or passive system. Chemical, sensible, and latent heat storages are the three types of TES. The thermal mass of the building structure might be used as a sensible storage system by the temperature change of the structure. Latent Heat Thermal Energy Storage (LHTES) outperforms other storages for its higher heat capability within a limited volume with minor expansion. It has a little temperature differential during a phase change (isothermal melting/solidification temperature). LHTES is more appealing than sensible storage [5]. The Free Cooling System (FCS) will store cool energy in the TES at night and reuse it throughout the day. FCS can only be used when the daily range temperature falls within the thermal comfort range, and it is most effective when the daily range temperature is the highest [6]. A significant quantity of energy could be kept in Phase Change Materials (PCMs) during phase shifts among solid, liquid, and gas phases in just a tight temperature change. Heat Transfer Fluids (HTF), such as air or water, have been widely used to melt and solidify PCM [7]. Recently, PCM applications have garnered attention due to their high density and commercial availability [8]. PCM is divided into three categories: inorganic, organic, and eutectic. Paraffin is an organic PCM widely used for its favorable thermophysical properties [9-11]. PCMs have a high storage density, making them ideal for storing thermal energy. The phase transition between solid and liquid is commonly used in TES because most PCMs are flammable at high temperatures [12]. Using PCM within TES is an excellent strategy for passive cooling and heating in buildings. Combining PCM and TES is an effective method for storing free cooling throughout the night for later usage during hot periods of the day [13]. PCM use is hampered by its high thermal resistance, which causes heat transfer to be delayed. Later, high thermal conductivity nanoparticles were added to microencapsulated PCM for heat transfer enhancement [14]. Heating and cooling systems could be eliminated or limited to specific hours of the day when PCM can be charged by cool night air and discharged by hot day air. Passive cooling/heating and energy-efficient technologies are concerned with improving indoor thermal comfort and lowering energy consumption. TES is considered a feasible alternative for energy-saving strategies [15]. As a storage medium, TES stores sensible heat in the structure of a building or a water storage tank [16]. LHTES has gained greater attention in recent decades than sensible heat storage due to the ability to charge or discharge heat over a relatively narrow temperature range, which describes the characteristics of LHTES [17]. The capacity of latent storage