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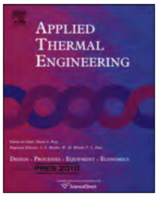

Discharging characteristics modeling of cool thermal energy storage system with coil pipes using *n*-tetradecane as phase change material

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ABSTRACT

The dynamic discharging characteristics of cool thermal energy storage system with coil pipes are studied by a discharging process model according to the energy balance of the phase change material and the heat transfer fluid. The *n*-tetradecane is taken as phase change material (PCM) and the aqueous ethylene glycol solution with 25% volumetric concentration is used as heat transfer fluid (HTF). It is presented that the variations of the phase change material temperature, heat transfer fluid temperature, melt fraction and cool release rate with time during the discharging process. The effects of the inlet temperature and the flow rate of the heat transfer fluid, and the diameter of coil pipes on the outlet temperature of the heat transfer fluid, melt fraction and cool release rate are discussed. The results indicate that the higher flow rate of the heat transfer fluid or the higher inlet temperature of the heat transfer fluid results in the higher cool release rate and the less time for discharging process. Compared to the inlet temperature and the flow rate of the heat transfer fluid, the diameter of coil pipes has little influence on the discharging characteristics.

1. Introduction

Cool thermal energy storage (CTES) plays a significant role in conserving available energy and improving its utilization, such as shifting on-peak demand to off-peak period. CTES is classified as sensible and latent heat cool storage systems. The advantages of the latent heat cool storage system in comparison with the sensible heat cool storage system are high cool storage density, small size of the system and a narrow temperature change during storing and releasing processes [1]. Many applications have been employed, for example, cool storage systems for air-conditioning, natural cooling of energy-efficient building. The application of cool storage technology shifts daytime air-conditioning loads to nighttime hours when the cooling load is low. Daytime cooling can be supplied by circulating the cooling medium rather than operating the compressor. Benefits can be received by both the consumer (lower energy costs, better space temperature control) and the utility (higher load factor, lower capital investment in new generating equipment) [2]. There are principally three types of cool storage system being developed, such as chilled water storage system [3], ice storage system [4] and inorganic and organic PCM storage system [5]. Fig. 1 presents the classification methods of cool thermal energy storage systems.

Chilled water storage systems need the largest storage tanks, but are easily compatible with existing chiller systems. During the charging mode, a tank is charged with water at 4–6 °C in stratified layers for later use in meeting cooling requirement. During the discharging mode, chilled water is supplied from the bottom of the tank and returned to the top of the tank. In this type of system, chilled water is stored at night in a storage tank, and is circulated at day through the cooling coil to accommodate the required cooling for the buildings. In order to determine an optimal operating condition for a thermal storage tank, numerical study with a bench scale experiment was performed to investigate the flow characteristics and thermal stratification mechanism. Major parameters such as hot water loading rate, temperature difference between hot water and cold reservoir, and geometrical variables were successfully validated by the experimental data [6]. Factors that influenced the performance of chilled water storage tanks were investigated. The results indicated that stratified storage tank consistently stratified well without any physical barrier and thermal efficiency of stratified storage tanks was as high as 90% [7].

Ice storage systems use the latent heat of fusion of water to store cooling capacity. In this system, ice may be generated by using glycol or brine solutions that enter the ice tanks from the chiller at temperature 3–6 °C below the freezing point of water. In all ice

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