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PII: S1359-4311(17)34194-7
DOI: https://doi.org/10.1016/j.applthermaleng.2017.10.153
Reference: ATE 11352

To appear in: Applied Thermal Engineering

Received Date: 21 June 2017
Revised Date: 26 September 2017
Accepted Date: 27 October 2017

Please cite this article as: H. Chirino, B. Xu, X. Xu, P. Guo, Generalized diagrams of energy storage efficiency for latent heat thermal storage system in concentrated solar power plant, Applied Thermal Engineering (2017), doi: https://doi.org/10.1016/j.applthermaleng.2017.10.153

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Generalized diagrams of energy storage efficiency for latent heat thermal storage system in concentrated solar power plant

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Abstract

Concentrated Solar Power (CSP) using phase change material (PCM) as the storage medium in the Thermal Energy Storage (TES) system is a promising technology for large scale utilization of solar thermal energy. This paper studied the energy storage efficiency (ESE) of latent heat thermal energy storage (LHTES) system using a previously developed enthalpy-based 1-D transient model, and three dimensionless parameters grouped from many of latent heat storage system properties were investigated. Finally, a series of generalized diagrams of ESE were provided for LHTES system, and the diagrams can serve as a convenient tool for solar thermal engineers, who can simply look up the charts to design and calibrate the size of TES system and operational conditions without doing complicated system level modeling and computations.

Key Words: Concentrated Solar Power (CSP), Latent Heat Thermal Energy Storage (LHTES), Phase Change Material (PCM), Energy Storage Efficiency, Generalized Diagrams

1. Introduction

Greenhouse gas (GHG) emission is of great significance for modern society due to the large scale civilization and industrialization in the past decades [1]. This has led to a considerably growing attention in renewable energies, such as solar energy. Photovoltaic (PV) and Concentrated Solar Thermal Power (CSP) are the two main solar energy technologies [2]. Recently, CSP is attracting more research attentions because it can store the excessive heat from the solar field and extend the power generation at night, CSP can also levelized the mismatch between energy demand and supply [3]. To make CSP technology competitive, thermal energy storage (TES) system filled with energy storage media is a critical component in all CSP plant [4].

TES system can be classified as sensible heat TES (SHTES), latent heat TES (LHTES) and a combination of both [5]. Presently, synthetic oils and molten salts (e.g. Solar Salt) are widely used in direct TES system as heat transfer fluid (HTF) and storage media in most of the Parabolic Trough Collector plants [6], more detailed information about the HTF and storage media for all the CSP plants in the world can be found in the map created by National Renewable Energy Laboratory’s CSP [7]. However, because LHTES system can offer a larger storage capacity in a relatively smaller storage volume compared to using SHTES system alone, it
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