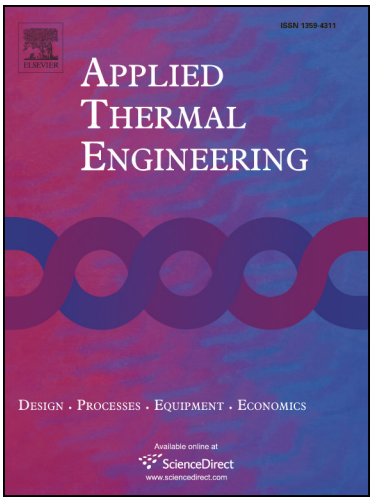

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Demonstration of a low cost, high temperature elemental sulfur thermal battery

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Abstract

Elemental sulfur is a low-cost energy storage media suitable for many medium to high temperature applications, including trough and tower concentrated solar power (CSP) and combined heat and power (CHP) systems. In this study, we have demonstrated the viability of an elemental sulfur thermal energy storage (SulfurTES) system using a laboratory-scale thermal battery. The SulfurTES battery design uses a shell-and-tube thermal battery configuration, wherein stationary elemental sulfur is isochorically stored in multiple stainless steel tubes and a heat transfer fluid (air) is passed over them through the surrounding shell. The safe and reliable operation was demonstrated for twelve thermal charge-discharge cycles in the temperature range of 200-600 ^{o}C, during which the SulfurTES battery stored up to 7.6 kWh of thermal energy with volumetric energy density range up to 255 kWh/m^3. Furthermore, the SulfurTES battery is operated in a hybrid thermal charging mode to demonstrate its ability to store surplus electrical energy. The present study establishes the feasibility of SulfurTES as a concept that could provide attractive system cost and volumetric energy density for a wide range of thermal energy storage applications.

Key words: Sulfur, SulfurTES battery, Thermal Energy Storage (TES), Volumetric energy density, Hybrid energy storage.

1. Introduction

For renewable energy to contribute significantly to the overall energy supply, low-cost storage options must be demonstrated and implemented. An effective implementation of a low-cost thermal energy storage (TES) system can achieve this goal by providing dispatchability to renewable energy resources including concentrated solar power (CSP) and can even be considered for storing surplus electric energy from photovoltaics (PV) and wind turbines during times of over-generation. Moreover, studies have shown that integration of thermal energy storage system with combined heat and power (CHP) system yields improved thermal performance and reduces fossil fuel consumption, resulting in favorable economics [1, 2].

The performance and value of a TES system are analyzed based on three important parameters viz.; the cost of energy storage, operating temperature range, and thermal performance. Several thermal energy storage systems, operating on various physical principles have been developed;

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