

Sulfur thermal energy storage





Overview

- A high-fidelity numerical model is developed for sulfur-based thermal.

A □ Cross-sectional area [m^2] AR □ Aspect ratio Bc □.

Thermal energy storage (TES) system bridges the gap between thermal energy supply and demand by providing dispatchability to renewable energy power generation. TES.

Inspired by modeling techniques proposed by Schumann [36], we developed an in-house 2D transient-state volume-averaged numerical model to predict the temperature distribution withi.

This chapter presents variation of each performance parameter to observe dependency of system performance on both geometric design and operating condition. This a.

Elemental sulfur is a promising storage material for low to high temperature thermal energy storage (TES) applications due to its high chemical stability, high heat transfer rate, and low cost. What is a sulfur-containing energy storage system?

The only commercially available sulfur-containing energy storage system is the Na/S battery, as illustrated in Fig. 10 (Wen et al., 2013), currently developed by Nippon Gaishi Kabushikigaisha (NGK Insulators, LTD). This system consists of liquid sulfur and sodium electrode, separated by a Na^+ – conducting membrane (Dunn et al., 2011).

What is the heat transfer behavior of sulfur?

The heat transfer behavior of sulfur was studied in two distinct temperature ranges: ~ 50 – 200 °C, and 200 – 600 °C. In the first stage of thermal charging, the tube surface was uniformly heated to 200 °C, and sulfur temperatures were recorded until steady state was achieved.

Why is sulfur important for battery energy storage?

Due to its abundance and favorable properties, sulfur can play an important



role in the major scale-up of battery energy storage. The two main applications are as the active material in metal-sulfur systems and as an electrolyte in the form of weak sulfuric acid, e.g., in lead-acid batteries.

What determines heat transfer performance in a sulfurTES system?

Heat transfer performance is inversely proportional to the characteristic length for both horizontal and vertical tubes. The more desirable tube orientation in a SulfurTES system depends on the tube and system dimensions.

What happens if sulfur temperature is below 275 °C?

For the sulfur temperatures below 275 °C, the viscosity of sulfur increases with sulfur temperature and decreases the overall heat transfer rate. Therefore, the temperature difference between the wall and the sulfur also increases, reflecting that the thermal response of sulfur is slowing down.

What is the energy equation for the volumetric-average sulfur temperature?

The energy equation for the volumetric-average sulfur temperature can be expressed as: $\rho c_p V \frac{dT_S}{dt} \cong h A (T_w - T_S)$ where V is the total sulfur volume, A is the total sulfur surface area, and T_w is the wall temperature, which is 600 °C for the charge condition and 200 °C for the discharge condition.



Sulfur thermal energy storage



Exploring the Limits of Empirical Correlations for the Design of ...

Studies of the charge and discharge behavior of elemental sulfur in high-temperature thermal energy storage systems have reported Rayleigh numbers on the order of ...

System performance analyses of sulfur-based thermal energy ...

Elemental sulfur is a promising storage material for low to high temperature thermal energy storage (TES) applications due to its high chemical stability, high heat transfer ...



Demonstration of a low cost, high temperature elemental sulfur thermal

Wirz et al. [21] proposed a novel concept to use elemental fluids, including sulfur, as the primary fluid for thermal energy storage. Sulfur is a molten medium over much of the temperature ranges important to CSP and therefore has many of the heat transfer and



The sulfur based thermochemical cycle for thermal energy storage

Sulfur dioxide disproportionation is one of three reaction steps that make up the sulfur based thermochemical cycle used for thermal energy storage of concentrated solar power.

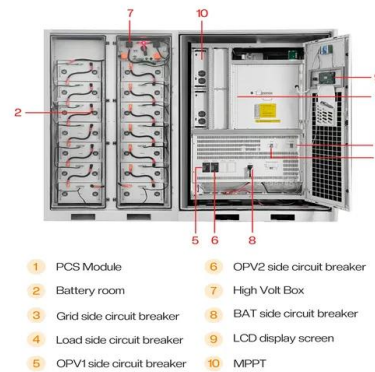


Molten-Sulfur Storage

Canned Heat: HPC Optimizes Molten-Sulfur Storage for Standby Thermal Energy More than 20 percent of US energy consumption is for "industrial-process heating": the use of thermal energy from burners or electric heaters that transform materials such as scrap metal or sand or milk into products like steel, glass, or pasteurized cream.

A solar sulphur cycle to make unlimited thermal ...

Most thermal energy storage materials aren't combusted when used for heat. Sulphur is different. Like a pile of coal, sulphur would be stored in a pile outside, and then, like coal, it is burned when the heat is needed. But ...



System performance analyses of sulfur-based thermal energy storage

Elemental sulfur is a promising storage material for low to high temperature thermal energy storage (TES) applications due to its high chemical stability, high heat transfer rate, and low cost. In this study, we investigate the performance of sulfur-based TES systems (SulfurTES) in a single-tank thermal battery configuration.



Heat transfer behavior of elemental sulfur for low temperature thermal

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@article{Nithyanandam2018HeatTB, title={Heat transfer behavior of elemental sulfur for low temperature thermal energy storage applications}, author={Karthik Nithyanandam and Amey ...



Heat transfer behavior of elemental sulfur for low temperature thermal

The sulfur-based thermal energy storage (SulfurTES) comprises of elemental sulfur encapsulated inside sealed pipes and heat transfer fluid (HTF) flowing in the shell (Fig. 1). In previous studies, we reported a laboratory scale demonstration of the SulfurTES[27]

Sulfur heat transfer behavior in vertically-oriented and ...

Elemental sulfur thermal energy storage (SulfurTES) is a promising low-cost solution for many medium to high temperature (300-1200 C) TES applications. Demonstrations of SulfurTES have shown



Thermofluidics of Sulfur-based Thermal Energy Storage

Thermal energy storage (TES) is crucial for future low-cost and large-scale (GWh) energy use and supply. Sulfur as a storage medium provides exceptional TES system cost efficiency and ...



System Performance and Cost Analyses of Sulfur-based Thermal ...

Elemental sulfur is a promising storage material for low to high temperature thermal energy storage (TES) applications due to its high chemical stability, high heat transfer rate, and low cost.



Sulfur heat transfer behavior for uniform and non-uniform thermal

Elemental sulfur is a low-cost, chemically stable thermal storage medium suitable for many medium to high temperature applications. In this study, we investigate the heat ...

Sulfur Thermal Energy Storage for Industrial Decarbonization

Sulfur Thermal Energy Storage for Industrial Decarbonization 1. DOE SETO CSP Program Summit 2019 Presentation 2.EIA Electric Power Monthly Table 1.1.A Net Generation from Renewable Sources 3. McMillan et al., 2023, NREL/TP-7A40-83020 The Problem





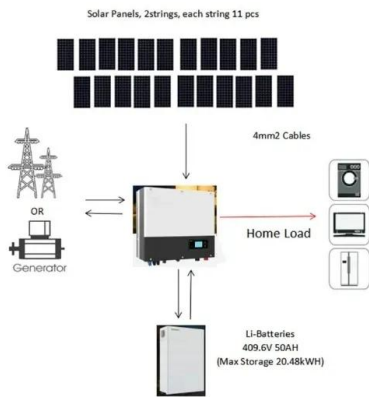
Solar energy storage using sulphur

The energy density of sulphur is 30 times higher than that of molten salt, which is currently used in solar thermal power plants to absorb, transport and store solar energy as high-temperature heat. Because sulphur can be stored in powder or liquid form, it can easily be transported and stored over long periods of time.



Sulfur heat transfer behavior in vertically-oriented and ...

Elemental sulfur thermal energy storage (SulfurTES) is a promising low-cost solution for many medium to high temperature (300-1200 C) TES applications. Demonstrations ...



System Performance and Cost Analyses of Sulfur-based Thermal Energy Storage

Author(s): Wang, Yide , Advisor(s): Wirz, Richard , Abstract: Elemental sulfur is a promising storage material for low to high temperature thermal energy storage (TES) applications due to its high chemical stability, high heat transfer rate, and low cost. In this study, we investigate the performance of sulfur-based TES systems (SulfurTES) in the temperature range of 50-600 oC ...

Sulfur heat transfer behavior in vertically-oriented and ...

Elemental sulfur thermal energy storage (SulfurTES) is a promising low-cost solution for many medium to high temperature (300-1200 C) TES applications. Demonstrations of SulfurTES have shown that the heat transfer behavior of sulfur in isochoric tubes is critical to system thermal performance.



Sulfur-based Thermal Energy Storage System using

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Exploring the Limits of Empirical Correlations for the Design of Energy

Sustainable energy technologies often use fluids with complex properties. As an example, sulfur is a promising fluid for use in thermal energy storage systems, with highly non-linear thermophysical properties. The viscosity of liquid-phase sulfur varies by four orders of magnitude due to polymerization of sulfur rings between 400 K and 500 K, followed by ...



Thermochemical Energy Storage

- Thermal and chemical energy storage, High and low temperature fuel cells, Systems analysis and technology assessment - Institute of Technical Thermodynamics o Chart 11 Thermochemical Energy Storage > 8 January 2013 Strategic Basis





One System, Many Models: Designing a Surrogate Model for Sulfur Thermal

Thermal energy storage (TES) helps reduce the carbon footprint of IPH systems by facilitating the utilization of renewable and waste heat sources. A promising new TES technology uses elemental sulfur as the heat-storage medium. The design of sulfur TES

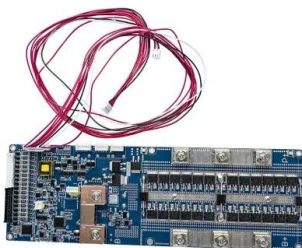


Elemental Sulfur as a Thermal Energy Storage Medium

Elemental Sulfur as a Thermal Energy Storage Medium Engineering Technology Department, College of Engineering Student Researchers: Andrew Liu, Evan Fullerton, Saul Ugarte Advisor: Dr. Reza Baghaei Lakeh Abstract The largest portion of the world's ever

High-Energy Room-Temperature Sodium-Sulfur and ...

Rechargeable room-temperature sodium-sulfur (Na-S) and sodium-selenium (Na-Se) batteries are gaining extensive attention for potential large-scale energy storage applications owing to their low cost and high theoretical energy density. Optimization of electrode materials and investigation of mechanisms are essential to achieve high energy density and ...



Sulfur heat transfer behavior in vertically-oriented isochoric thermal

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Areas of Interest: DOE Invests Nearly \$7.6M to Develop Energy Storage

Low Cost Sulfur Thermal Storage for Increased Flexibility and Improved Economics of Fossil-Fueled Electricity Generation Units -- Element 16 Technologies Inc. (Glendale, California) will undertake a feasibility study of ...



Charge and discharge behavior of elemental sulfur in isochoric ...

Thermal energy storage with elemental sulfur is a low-cost alternative to molten salts for many medium to high-temperature energy applications (200-600 C). In this effort, by examining elemental sulfur stored isochorically inside isolated pipes, we find that sulfur

Sulfur heat transfer behavior in vertically-oriented and non

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Exploring the Limits of Empirical Correlations for the Design of Energy

As an example, sulfur is a promising fluid for use in thermal energy storage (TES) systems, with highly nonlinear thermophysical properties. The viscosity of liquid-phase sulfur varies by four orders of magnitude due to polymerization of sulfur rings between 400 K and 500 K, followed by depolymerization of long rigid chains, and a decrease in viscosity, as ...



Development and Testing of Low-Cost Sulfur Thermal Energy Storage

The research team developed and validated the operation of a combined cooling, heating, and power plant integrated with novel sulfur thermal energy storage technology for adoption in commercial sectors. This technology uses low-cost molten sulfur as the storage fluid that can store and discharge heat efficiently. Element 16 adds flexibility to combined ...



Researchers develop promising and 'very cheap' method for storing ...

In state-of-the-art solar thermal energy systems (which harness concentrated solar energy as heat), molten salt is the material of choice for storing energy, as the SolarPACES organization explained. But sulfur can be far cheaper and provide higher energy density (basically the amount of energy stored relative to the material's mass), allowing for greater storage.

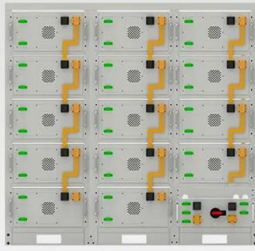
Heat Transfer Behavior of Sulfur for Thermal Storage Applications

Elemental sulfur thermal energy storage (SulfurTES) is a promising low-cost solution for many medium to high temperature (300-1200 C) TES applications. Demonstrations of SulfurTES have shown



Sulfur heat transfer behavior for uniform and non-uniform thermal

A comprehensive system-cost model showed that sulfur thermal energy storage systems exhibit superior thermal performance at the storage cost that is well-below DOE target of \$15/kWh [37, 38]]. Thus, previous analyses have shown the potential of elemental



Battery String-S224

- 1C Charge/Discharge
- Easy configuration and maintenance
- Power supply can be single battery string or parallel battery strings

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