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A Particle-Based Circulating Fluidised Bed for Continuous Hot Air Production in Solar Thermal Applications

Summary

A novel circulating fluidised bed (CFB) system is proposed for particle-based solar thermal applications. The system integrates a riser, separator, solar receiver, and thermal energy storage (TES) in a single loop. Silicon carbide (SiC) particles (~500 µm) act as both heat transfer and storage medium at approximately 150 °C. The study focuses on hydrodynamics, gas–solid heat transfer, and circulation stability. The integrated TES enables continuous operation despite solar intermittency. The system offers a scalable solution for supplying hot air to small- and medium-scale industrial processes.

Keywords: Circulating fluidised Bed, thermal energy storage, particle-based hot air production

Field of application for the findings: Sustainable Heat for Industrial Process, Thermal Energy Storage

Addressed audience: Researchers and engineers in solar thermal energy systems

Short Abstract

This study presents a novel application of a circulating fluidised bed (CFB) system for controlled-temperature air generation in concentrated solar power (CSP) applications. Unlike conventional solar receivers and thermal energy storage (TES) systems, the proposed configuration integrates particle-based heat absorption, circulation, and storage within a closed loop. Silicon carbide (SiC) particles with a mean diameter of 500 µm are employed as the heat transfer and storage medium due to their high thermal conductivity and stability. The system operates at moderate temperatures (~150 °C) and enables scalable, continuous hot air supply for small- and medium-scale industrial processes. The key novelty lies in combining a solar receiver, particle circulation, and TES within a compact CFB architecture suitable for deployment in elevated solar tower configurations.

The primary objective of this work is to investigate the hydrodynamic and thermal performance of a lab-scale CFB system comprising a riser, particle separator, solar receiver, and TES unit. The riser facilitates gas–solid interaction and particle transport, while the separator ensures efficient particle recirculation. The receiver is designed to simulate direct irradiation conditions, and the TES unit enables continuous operation by storing thermal energy within the circulating particles. Experiments are conducted using air as the fluidising medium at superficial velocities sufficient to sustain circulating regimes, with SiC particles at operating temperatures around 150 °C. Key parameters under investigation include particle circulation rate, heat transfer characteristics, temperature distribution, and system stability under varying flow conditions.

The findings demonstrate stable particle circulation, efficient heat transfer between gas and solid phases, and the capability of the system to deliver a continuous hot air stream. Integration of TES within the CFB loop reduces thermal intermittency associated with solar input, thereby enhancing system reliability. The results offer insights into scaling the technology for industrial applications and its integration within solar tower fields at elevated heights.

A complete extended abstract, including detailed experimental methodology and comprehensive results, will be submitted closer to the conference date. This subsequent submission will present the full analysis of the system’s hydrodynamic behaviour, heat transfer performance, and operational stability, providing a more in-depth evaluation of the proposed circulating fluidised bed configuration for solar thermal applications.