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Development of a 1D Numeric model for axial pebble bed Thermal Energy Storage (TES) as a design decision tool for waste heat recovery in steel plants

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Heat recovery from waste gas in heavy industries, such as steel plants, is crucial for enhancing energy efficiency and sustainability. This process captures thermal energy released during production and repurposes it for other applications within the plant. This approach not only reduces operational costs but also minimizes energy wastage and lowers greenhouse gas emissions, supporting global efforts to combat climate change. Integrating heat recovery technologies thus represents a significant step towards more eco-friendly and cost-effective industrial operations. One of the key challenges in implementing such energy efficiency solutions lies in designing the core reactor/devices and auxiliary systems to ensure optimal integration and achieve the expected benefits.

This work highlights the numerical modeling of heat transfer and hydrodynamics within an axial pebble bed thermal energy storage (TES) system as a preliminary tool for testing use cases and optimizing design decisions for waste heat recovery in steel plants. It includes the validation of the developed model with experimental data from both experiments and literature sources. A sensitivity analysis using the model reveals the importance of optimizing the specific heat capacity of the solid particles, the height of the pebble heater, and the charging time to maximize energy extraction from the waste heat source. The diameter of the solid particles also impacts the effective thermal conductivity of the TES, due to its direct proportionality to the radiative contribution of the thermal conductivity, while also influencing the pressure drops across the system.

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