Numerical Analysis of Waste-Based Thermal Energy Storage System for CSP Plants

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Abstract

Thermal energy storage (TES) is an enabling system that provides uninterrupted energy from concentrated solar power (CSP) plants. Packed-bed TES systems have great opportunity to significantly enhance the cost-effectiveness, efficiency and sustainability of CSP plants by employing an affordable and sustainable packing material. The objective of this study is to design a packed bed TES system with a maximum storage capacity of 40 kWh, specifically tailored to store heat within the temperature range of 290 – 565 °C, thereby making it suitable for integration into CSP plants. Performance and thermal behavior of demolition waste-based packed-bed TES system was assessed through numerical analysis. The results demonstrate that a high discharging efficiency of 96.7% was achieved when the HTF flow rate was set at 300 kgh $^{-1}$. However, it is important to note that at lower HTF flow rates, heat loss increases, leading to a decrease in discharging efficiency to 93.7%. The experiment also revealed a uniform thermal gradient within the packed-bed TES system, up to a fluid flow rate of 300 kgh $^{-1}$. It is worth mentioning that lower flow rates can further improve the stratification effect; however, they may also result in increased heat loss and reduced storage capacity. Based on these findings, an optimal flow rate range of 100-200 kgh $^{-1}$ is recommended to achieve the best performance for the packed-bed TES system.

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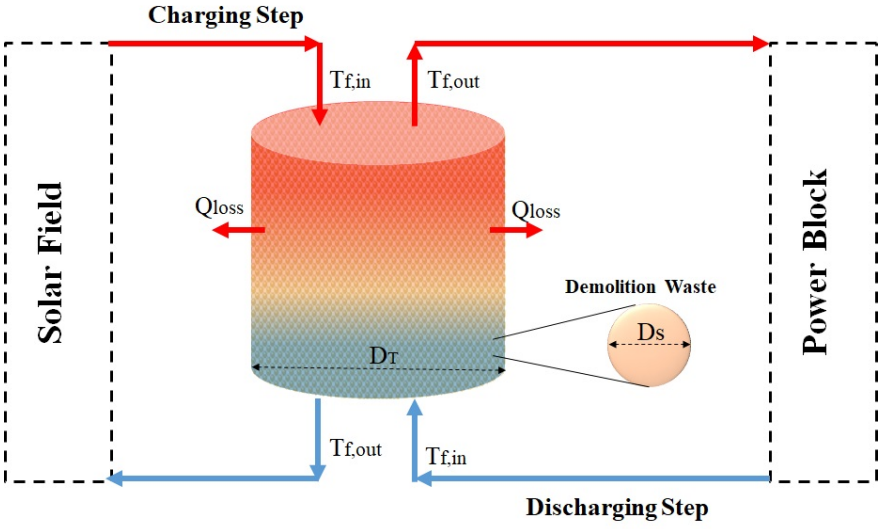

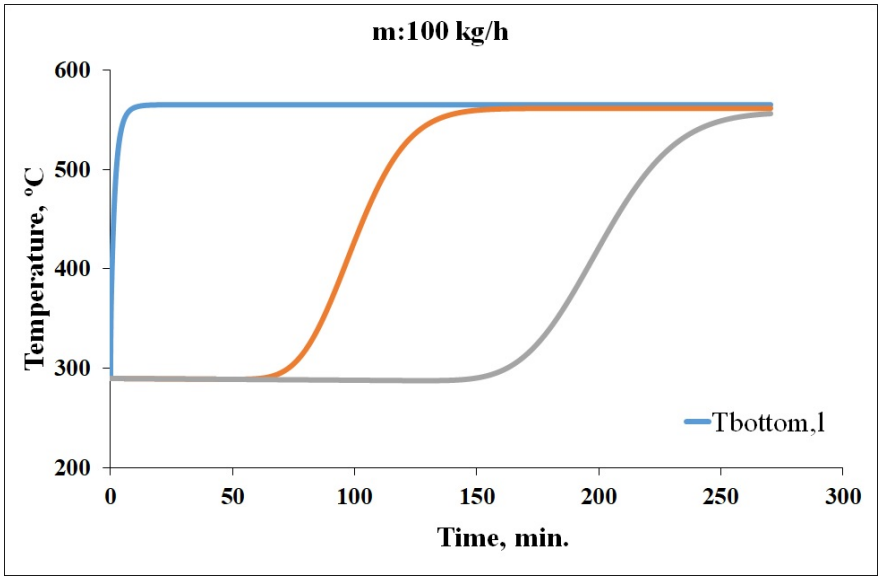

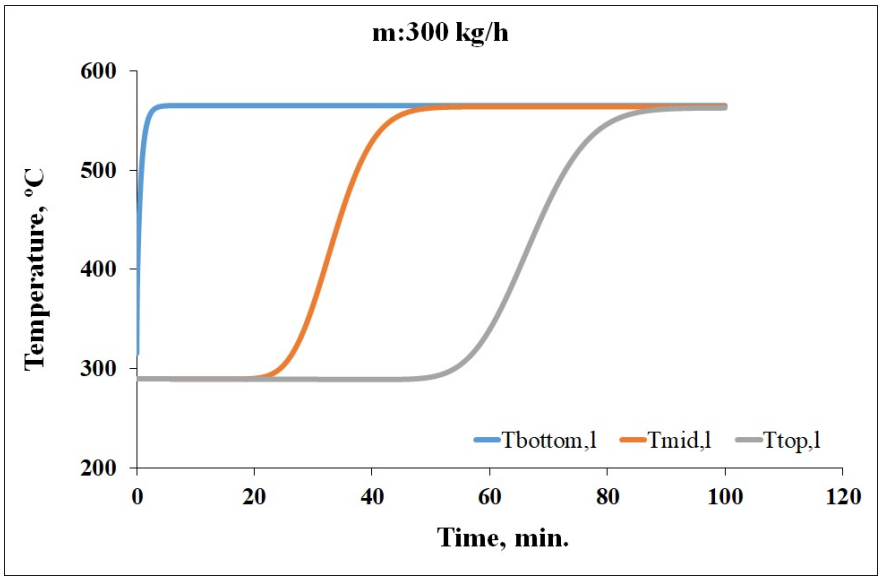

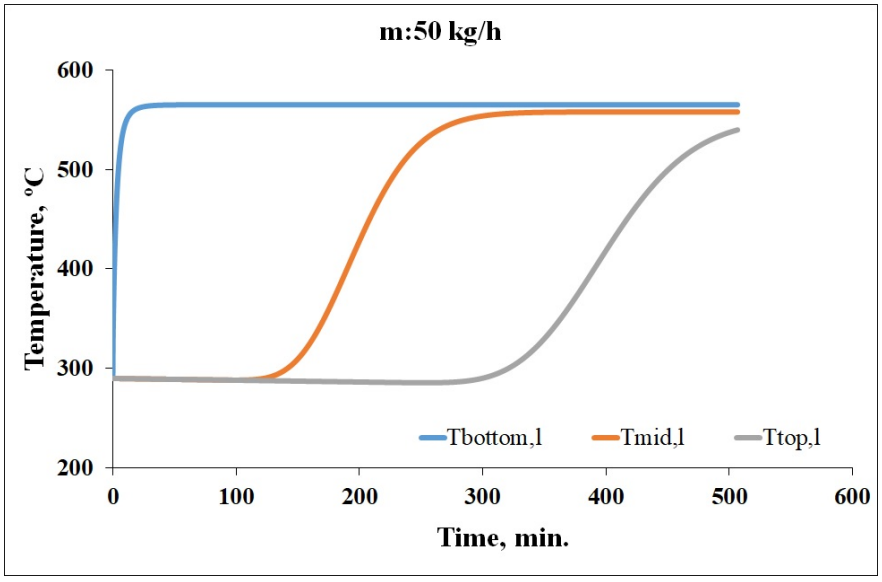

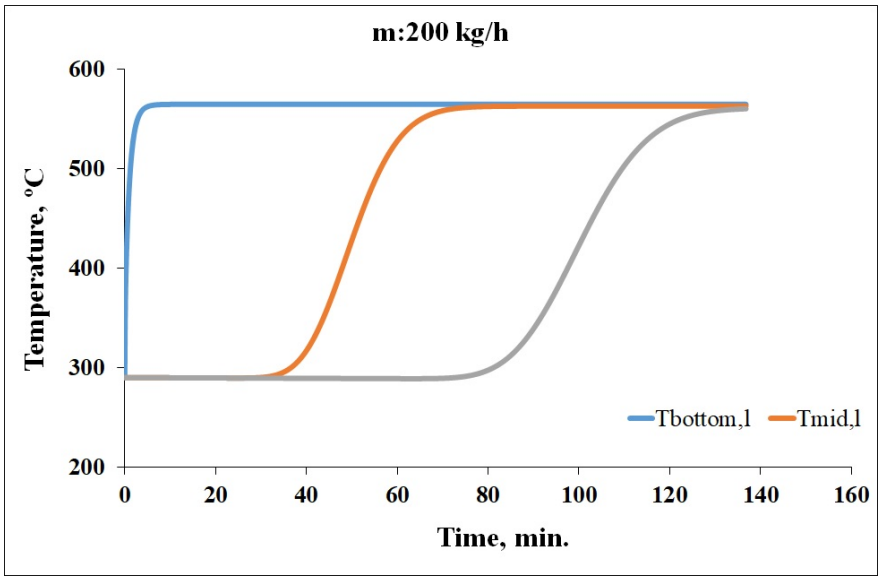

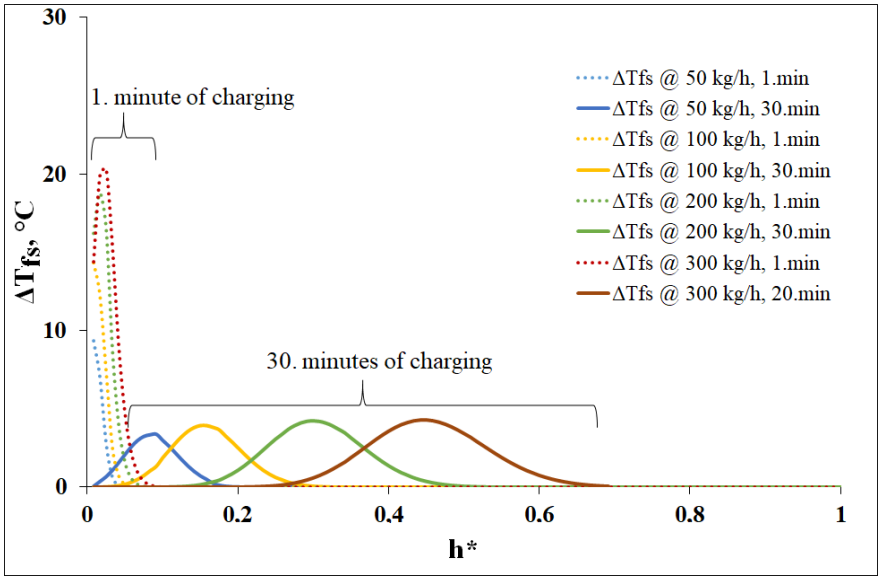

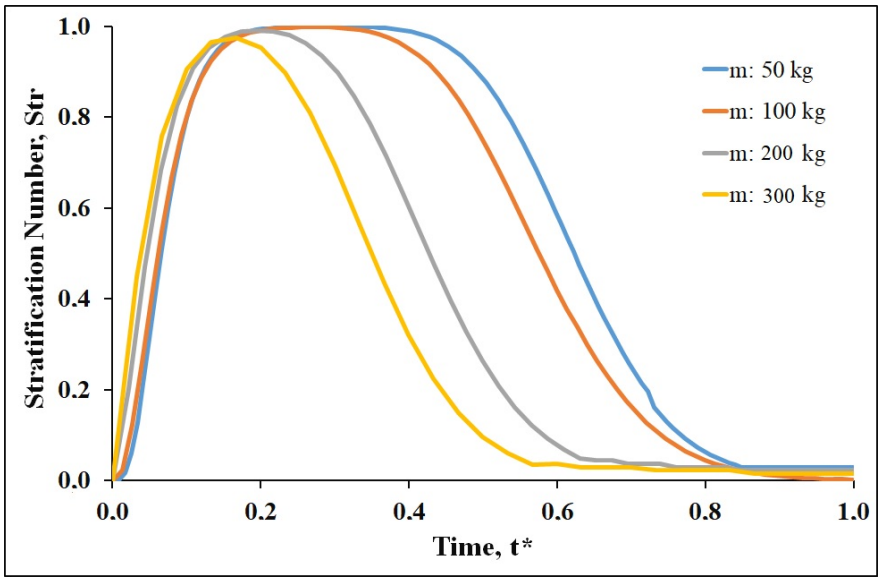

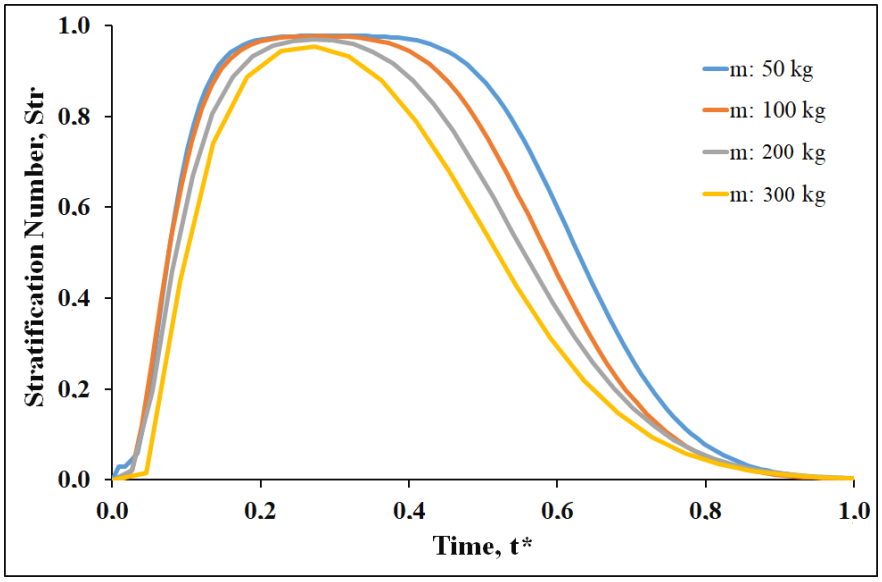

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