Computational analysis of an air-based thermal energy storage system using medium-to-high temperature PCMs

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High-temperature Thermal Energy Storage (TES) systems play a crucial role in industrial waste heat recovery and concentrated solar power applications [1]. This study presents a 3D computational fluid dynamics (CFD) analysis of an air-based TES system integrating medium-to-high temperature Phase Change Materials (PCMs). Using COMSOL Multiphysics, the non-isothermal conjugate heat transfer between the transient airflow and the solid matrix embedded with macro-encapsulated PCM is evaluated. The numerical framework implements an enthalpy-based formulation with temperature-dependent properties to accurately model the latent heat transitions and phase change kinetics during charging and discharging cycles[2][3]. The primary goal is to investigate the thermal response, phase front evolution, and overall energy density of the storage unit. Ultimately, this computational model aims to assess the effectiveness of PCM integration compared to sensible-only storage and to provide design guidelines for optimizing heat transfer efficiency in high-temperature air-based energy storage architectures.

References

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