Thermodynamic Analysis of sCO_2 Energy Storage System

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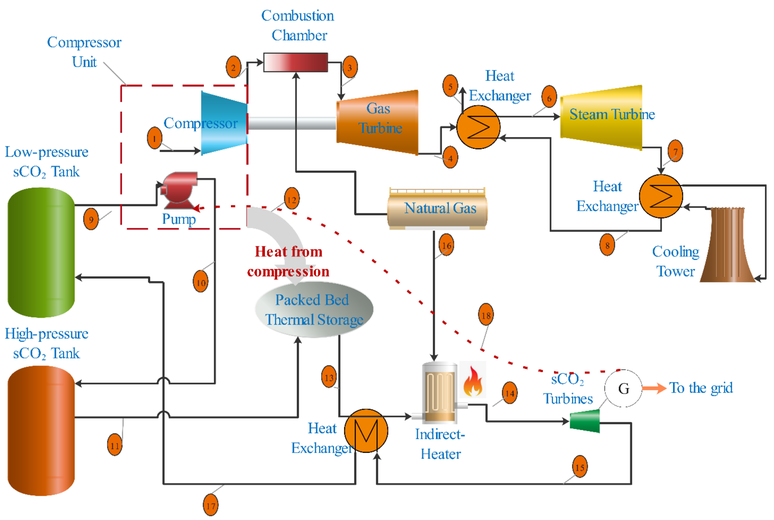
Motivation

Energy storage is a critical technology for the energy utility industries for more reliable and affordable energy supply, cleaner environment, and stronger energy infrastructure. Supercritical carbon dioxide (sCO_2) thermal energy storage systems have been previously studied for integration with renewable energy systems.

Cycle Overview

This work seeks to investigate the advantages of integrating sCO_2 thermal energy storage systems with existing natural gas combined cycle (NGCC) power plants for waste heat recovery. Energy from compression is stored in the packed bed, where it can later be extracted and used to generate electricity with a turbine. This is expected to improve efficiency and improve short to mid term load response.

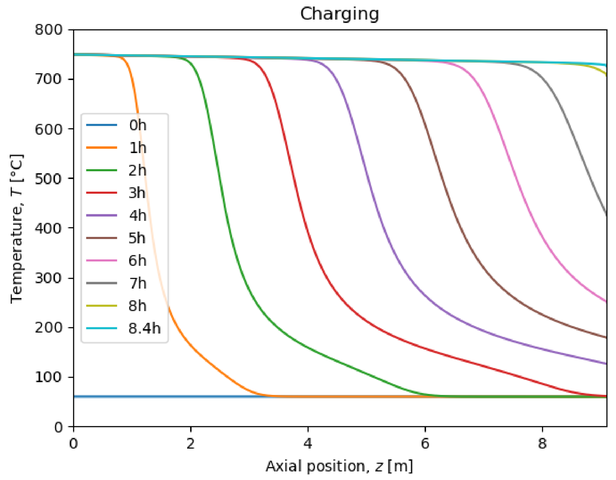


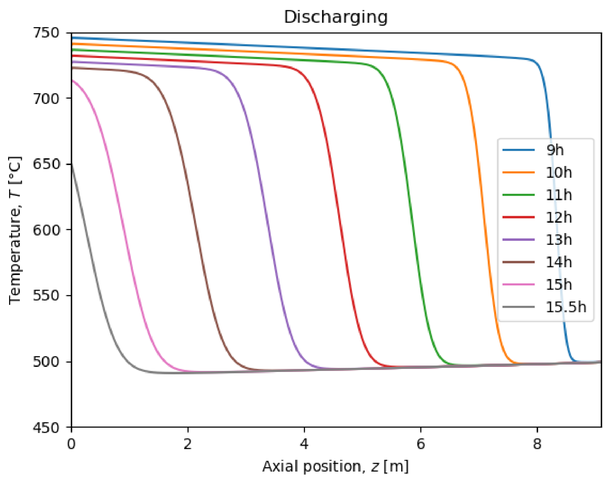
Model

The packed bed thermal energy storage model used for this work is from Battisti et al. [1]. The 1-D porous medium model accounts for heat transfer between the sCO_2 heat transfer fluid (HTF) when charging and discharging, as well as heat loss to the walls/lids of the tank and its surroundings. This model was implemented in Python for the present work.

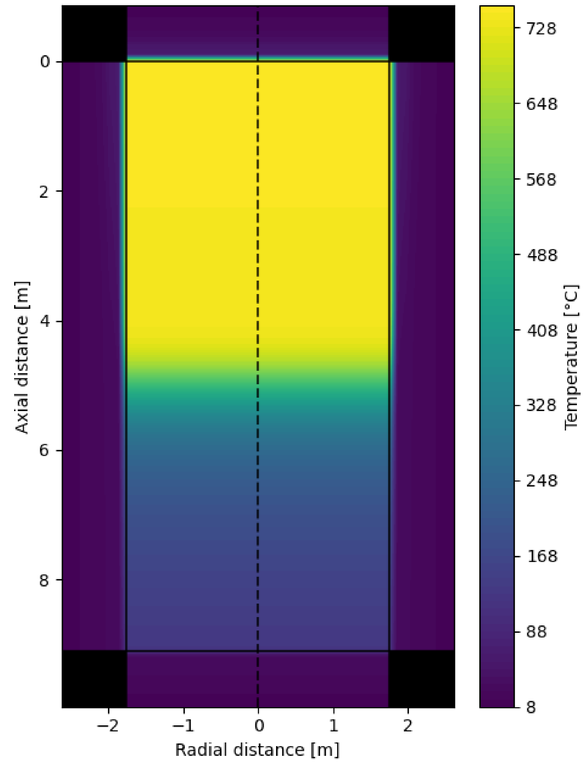
Results and Discussion

The sCO_2 packed bed thermal energy storage model code was validated against the example case [1] to verify correct implementation prior to the thermodynamic analysis of the cycle. Shown below are the temperature profile in the packed bed during charging and discharging operations.





Additionally, the temperature profiles in the heat transfer fluid and in the walls and lids of the tank are shown to the right. The present implementation was found to accurately calculate the expected charge and discharge times.



Future work

Integration of the sCO_2 energy storage code into process modeling software for the integrated energy storage and NGCC analysis and optimization is ongoing.

Acknowledgments

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References

[1] F. G. Battisti, L. A. de Araujo Passos, and A. K. da Silva, "Performance mapping of packed-bed thermal energy storage systems for concentrating solar-powered plants using supercritical carbon dioxide," Applied Thermal Engineering, vol. 183, 2021, doi: 10.1016/j.applthermaleng.2020.116032.