ME – PhD Thesis Defence

On the development of sensible heat storage for concentrated solar power applications: Thermo-fluid management and materials

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ABSTRACT

Sensible heat storages have extensive use in thermal energy deployment, including concentrated solar power (CSP) applications. Usually, CSP pants demand various techno-economic features in sensible heat storage, such as low-cost, high-capacity, efficiency, and ease of operation. These requirements demand investigations to assess and develop novel strategies to improve the efficacy of sensible heat thermal energy storage (TES) technology. Accordingly, the present study focuses on thermo-fluid management and material characterization for stratified TES.

Computational fluid dynamics simulations were employed to analyze near-inlet thermal blending of hot and cold heat transfer fluid (HTF), molten salt, for a single-tank sensible heat TES system. Accordingly, a hemispherical diffuser is developed. In addition, a mathematical index is proposed to quantify the degree of thermal stratification. Further, experiments were conducted for thermosyphon charging of single-tank stratified storage including both continuous and pulsatile charging at low (150 °C) and high (250 and 300 °C) temperatures. Dowtherm-A oil was used as the HTF, and the thermal expansion of HTF was accommodated in an expansion tank via two different designs (top and bottom connections from the storage tank to the expansion tank).

From a materials viewpoint, high specific heat capacity (C_P) is essential to improve the energy density of the storage; which can be improved by adding nanoparticles to molten salt. However, the literatures show both increment and decrement in C_P. Since difficulties are associated with identifying explicit relations between molten salts and nanoparticles due to complex molecular interactions, we inquired whether there are common patterns/clusters in the nanofluid samples reported in earlier studies by employing unsupervised machine learning methods: Hierarchical cluster analysis (HCA) and Principal component analysis (PCA). Finally, a comparative analysis is presented to capture the measurement variability in nanofluid samples under random sampling. In this analysis, the DSC test is employed on small-sized batches (< 10 mg) and the T-history method on large-sized batches (~ 20g), and the C_P values of both tests are compared using a nonparametric statistical test, Mann-Whitney U Test.

ABOUT THE SPEAKER

Dipti Ranjan Parida is a PhD student in the Department of Mechanical Engineering, IISc, Bangalore. He completed his MTech from the Indian Institute of Technology, Bhubaneswar, in 2017. Subsequently, he joined IISc as a PhD student in August 2017. His research interests include multi-physics modeling of thermofluidic systems, data-driven analysis, and material characterization. His dissertation focuses on sensible heat thermal energy storage systems for high-temperature concentrated solar power plant applications.