Density Stratified Thermal Energy Storage System and Associated Fluid Dynamic Perturbations

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Abstract:

The hunger of humankind for energy has reached unprecedented levels with the ever-rising industrialisation and global population surge. We are witnessing a global economic evolution towards a clean, affordable, sustainable and reliable sources of energy which could transform our lives and the planet itself. The mismatch between the supply of solar energy which is one among the most promising renewable energy and the demand for its utilization, compel us to incorporate a solar energy storage. Such storage systems are essential in various fields including power generation sectors like power plants based on solar thermal, thermal (non-renewable) and nuclear.

The study is primarily an experimental investigation of single tank sensible stratified thermal energy storage which sheds light on the experimental procedure to establish a stable and sustainable thermocline thermal energy storage. Moreover, in order to have an understanding of the causes of capacity loss in such stratified storage tanks, various studies are conducted, both numerically as well as experimentally. The performance of the TES depends on the integrity of the temperature gradient region (thermocline thickness). Mixing and spatio-temporal perturbations at the thermocline region is the foremost cause of capacity loss and the most important mechanism which destroys the stratification is vortex/plume entrainment in a thermocline-based storage tank. In a stably stratified TES, vortex entrainment occurs when a relatively cold mass of fluid is injected into the tank. Vortex-thermocline interaction creates vortices by baroclinicity, leading to entrainment and mixing. Hence any vortex entrainment in the thermocline region is critical and determines the efficiency of such thermal storages.

Density stratification formed in terms of salinity as an analogy to that due to temperature as well as the effect of disturbances are studied. As a corollary, various distributors are compared numerically and tested the advantage of a novel distributor design. The work provides quality experimental data in order to meet with its inadequacy in the related literature as well as deeper understanding into the establishment of a stable and sustainable thermocline thermal energy storage