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Investigation of Transient, Turbulent Natural Convection in Vertical Tubes for Thermal Energy Storage in Supercritical CO_2[1]

REZA BAGHAEI LAKEH, ADRIENNE S. LAVINE, H. PIROUZ KAVEHPOUR, RICHARD E. WIRZ, University of California, Los Angeles — Heat transfer can be a limiting factor in the operation of thermal energy storage, including sensible heat and latent heat storage systems. Poor heat transfer between the energy storage medium and the container walls impairs the functionality of the thermal storage unit by requiring excessively long times to charge or discharge the system. In this study, the effect of turbulent, unsteady buoyancy-driven flow on heat transfer in vertical storage tubes containing supercritical CO_2 as the storage medium is investigated computationally. The heat transfer from a constant-temperature wall to the storage fluid is studied during the charge cycle. The results of this study show that turbulent natural convection dominates the heat transfer mechanism and significantly reduces the required time for charging compared to pure conduction. Changing the L/D ratio of the storage tube has a major impact on the charge time. The charge time shows a decreasing trend with $\mathrm{Ra_L}$. The non-dimensional model of the problem shows that Nusselt number and non-dimensional mean temperature of the storage fluid in different configurations of the tube is a function Buoyancy-Fourier number defined as of $\mathrm{Fo_L} * \mathrm{Ra_L^m} * \mathrm{L/D}$.

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