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Abstracts:

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Experimental Study of a Coil Heat Exchanger in a Latent Heat Energy Storage System for Solar Domestic Hot Water Heating

Energy storage is one of the most important components of a solar domestic hot water system (SDHW) due to the conflicting time dependency of both the availability of solar radiation and the hot water demand. Conventional systems utilize water storage through sensible heating, however some applications have space restrictions that would not allow for the usage of conventional water storage systems. Latent heat energy storage systems (LHESS) use phase change materials (PCMs) as the storage medium, which possess higher storage densities than conventional systems. This research aims to validate a design model for a coil in tank setup that insures uniform heat transfer from the coil in all three directions.

Conduction is the dominant mode of heat transfer during the discharge process. Due to the transient nature of simultaneous heat diffusion and storage, Fourier number analysis is used in order to reach uniform heat diffusion rates in all directions. Fourier number is defined as the ratio of the heat conduction rate to the rate of thermal energy storage in a solid. Therefore in order to achieve uniform diffusion rates, the characteristic lengths must be equated in all directions. Furthermore, the analysis using the Fourier number along with experimental data could be extended to develop a scale up method to determine the characteristic dimensions of the tank and heat exchanger in order to achieve a desired charging/discharging time.

The experimental setup was built and tested at NSCC Applied Energy Research Lab in collaboration with the Lab of Applied Multiphase Thermal Engineering at Dalhousie University. An experimental investigation was conducted on an initial tank filled with the dodecanoic acid (lauric acid) and coupled with a simple helical copper coil. Two types of charging experiments were performed: Real-Time solar experiments and controlled hot water tank experiments at 60, 70 and 80°C. Discharging experiments were conducted by circulating municipal water through the coil. Spatial temperature distributions were recorded throughout the tank, as well as determining heat transfer rates from the coil fluid energy balance.

A new tank was built based on the Fourier analysis model and is currently undergoing validation for the hypothesis of uniformity and proportionality of the characteristic time to the observed experimental time. The experiments that were conducted for the initial tank will be replicated which will allow for a parametric study of the heat exchanger design. The validation of the model will serve as a general tool for designing and scaling simple coil in tank systems for LHESS applications in SDHW systems.