An experimental method to determine the thermal contact resistance and state of charge of PCM materials via pressure sensors in a heat flux meter apparatus

Joseph Rendall, ORNL

Thermal contact resistance between heat exchangers and phase change materials (PCMs) influences the overall performance of the thermal energy storage (TES) system and cannot be ignored when PCMs experience large volume changes during phase change. Meanwhile, determining the state of charge (e.g., amount of PCM in the liquid and solid phase) operando is difficult as most of the storage occurs at a narrow temperature range or even at a constant temperature. Furthermore, temperature-based measurements can be misleading as PCM materials all exhibit certain subcooling effects upon freezing. The presentation will describe how a heat flow meter apparatus (HFMA) was modified to measure the thermal contact resistance and state of charge (SOC) throughout the phase change process in situ and how this information can be used to determine the SOC in operando. First, resistive-based pressure sensors were added to the HFMA, where the heat flow measurements of the HFMA were used to determine the overall resistance for a baseline case without a PCM sample and to determine temperature-based effects (e.g., sensor thermal drift and temperature-dependent conductivity). Then, a PCM sample was added, and the thermal contact resistance was reported as the temperature swept in the HFMA causing the PCM to undergo phase change. Lastly, the SOC vs. resistance reading relationship was developed when the PCM was undergoing phase transition at constant temperature and constant pressure in the HFMA. The results show that two linear functions can represent the SOC in the freezing and melting process or a parabolic function to model both processes. HFMA with the addition of a pressure measurement determined the SOC of a PCM material with little hysteresis. The measured thermal contact resistance values are helpful to ensure bulk storage systems keep an appropriate thermal contact resistance when installed in the field by controlling contact pressure via an expansion bladder. When PCM is deployed in large-scale storage applications, a simple pressure sensor or deflection sensor on an expansion bladder can be used to give real-time SOC information in the field. These types of pressure-based sensors are desired as the current state-of-the-art sensors are temperature measurements, which are only local measurements.