MODELLING AND CHARACTERIZATION OF AN ICE STORAGE FOR OPTIMIZED OPERATION

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Abstract – Ice storage systems (ISS) present a flexible option for the storage of thermal energy. However, due to the distinctive nature of the phase change, issues arise with ISS that are not present in conventional thermal energy storage systems. This mainly concerns the determination of the state of charge (SOC) of the ice storage during operation, as the SOC of conventional sensible thermal energy storages can be determined by a simple temperature measurement. Nevertheless, this method is not sufficient for ISS due to the constant temperature during phase changes. However, knowledge of the SOC is essential for optimum operation of the whole system. Therefore, this work deals with the modelling and experimental characterization of an ISS. The mathematical modelling is performed using a one-dimensional, discrete, dynamic model. The integration of fluid property models allows a continuous calculation of the thermodynamic properties of the fluid during the simulation. The model calculates the heat transfer coefficients, the heat flow, the transported energy and the current SOC of the ISS. Furthermore, the model has been designed to be as flexible as possible. Therefore, both icing and de-icing processes can be simulated (de-icing process shown in Figure (a)). Additionally, a variety of fluid mixtures, including water with distinct glycol proportions, can be simulated. In order to validate the results obtained in the simulation, an ice storage setup with stainless steel spiral heat exchanger has been equipped with appropriate measurement equipment. This includes temperature sensors at different locations of the ice storage tank as well as the measurement of all necessary fluid properties of the heat transfer fluid. Additionally, a capacitive sensor placed alongside the heat exchanger is employed to measure the current degree of icing in the storage (Figure (b)). Ice and water have different dielectric constants, which is utilized here to determine the ice thickness. Initial comparisons between the simulation and measurement results demonstrate a high degree of agreement. This work uses the local measurement and simulation data to make a global state of charge estimation for ISS.

Keywords – Capacitive measurement; heat transfer; Phase Change Material (PCM); State of Charge (SOC); thermal energy storage
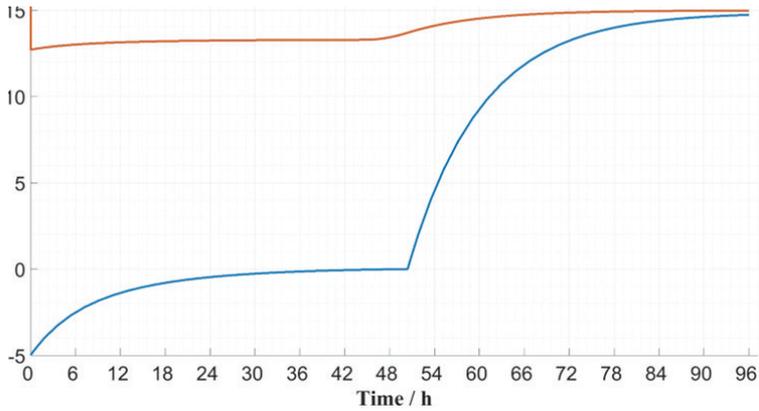
(a) Simulated temperature curve of a de-icing process
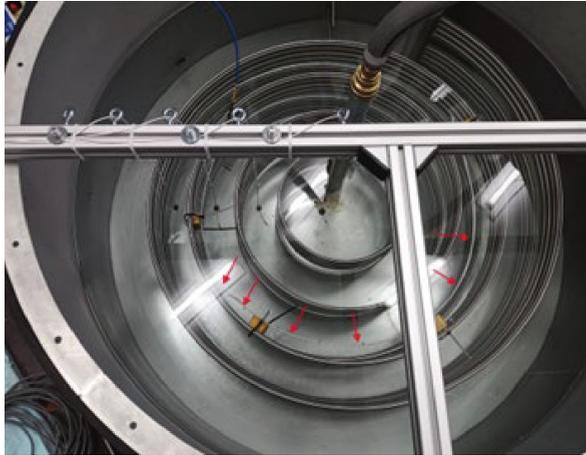
(b) SOC determination setup

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