COMSOL CONFERENCE
2015 KUALA LUMPUR

Thermal Analysis Of A Sealed Battery Power System Enclosure For Underwater Operations

Chiew Hay King Joel

Temasek Polytechnic, Clean Energy Research Centre

Singapore

Abstract

One of the most common causes of failure of the LiFePO4 (Lithium Iron Phosphate) battery is high temperature. Battery failure by heat can be caused by charging/discharging at high current as well as built up thermal energy in a sealed enclosure. Maintaining the components at a lower temperature helps in attaining reliable and safe operations of the system. However, due to the nature of the operating environment, the battery system has to be water-tight sealed for protection from the hydrostatic pressure. Therefore, it is crucial to monitor the temperature of the batteries within the enclosure and simulate the external environmental conditions during the discharging cycle of the power system.

According to the product specification manual, the batteries must not exceed 50°C. The enclosure is made of acrylic and the internal structures are made of aluminium. The model was designed in Solidworks, as shown in Figure 1, and imported into COMSOL Multiphysics for the thermal simulation.

Due to the symmetrical geometry of the model, the symmetry function in COMSOL was used to simulate the other half of the model. A few insignificant components had been removed from the model to expedite the simulation time.

The actual physical model is shown in Figure 2.

COMSOL Multiphysics was used to simulate the heat flux from the battery cells via conjugate heat transfer physics which consist of laminar flow and heat transfer in solids and fluids. Laminar flow function was used to simulate natural convection of air within the sealed enclosure. Heat transfer in solids and fluids were used to simulate conduction of heat through the materials and air within the enclosure. A constant temperature was applied to the outer surface of the model.
The preliminary results from the simulation are as shown in Figure 3.

As seen in Figure 3, the model was set at a simulation time of 14400 seconds (4 hours) at a constant heat flux and produced a maximum temperature reading of 38.7°C, which complies with the limit of 50°C.

The result presented in the simulation indicates that the battery power system is capable of operating for 4 hours continuously without exceeding the temperature limit. With addition of a thermal management system, such as a phase changing material to store the thermal energy, the overall enclosure temperature and be brought down to level where the battery performance is optimal.

However, the simulation results needs to be verified by an experimental result. Hence, the next step is to conduct an experiment, based on a physical model, to prove the accuracy of the simulation.

Reference

Jiangong, Zhu et al. 'Preliminary Study of a Distributed Thermal Model for a LFP Battery in COMSOL Inc. Multiphysics (MP) Software'. IEEE 5.13 (2013): 256 - 260.

Muthuraj, M, and N Parameswaran. 'Thermal Analysis of Sealed Enclosure for Over the Ocean Application'. 19th IEEE SEMI-THERM Symposium 0-7803-7793-1.02 (2003): 134 - 137.

Rad, Mojtaba Shadman et al. 'Thermal Modeling of Cylindrical LiFePO4 Batteries'. Journal of Modern Physics 04.07 (2013): 1-7.

Toma, Daniel Mihai et al. 'Study on Heat Dissipation and Cooling Optimization of the Junction Box of OBSEA Seafloor Observatory'. IEEE/ASME Transactions on Mechatronics 20.3 (2015): 1301-1309.

Figures used in the abstract

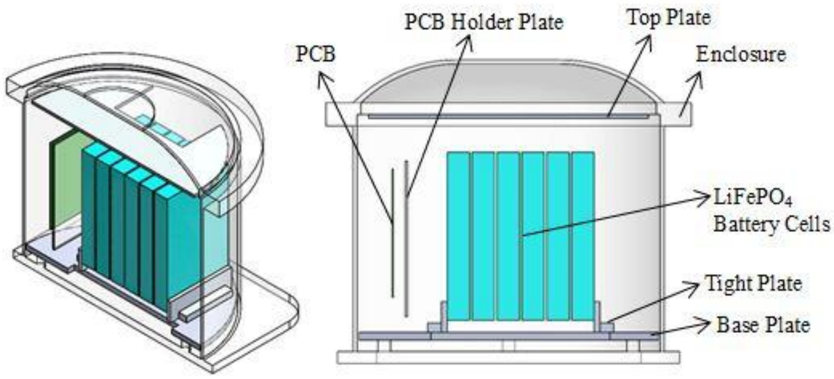

Figure 1: Solidworks Model (Left: Isometric View, Right: Front View)

Figure 2: Physical Model of the Battery Power System

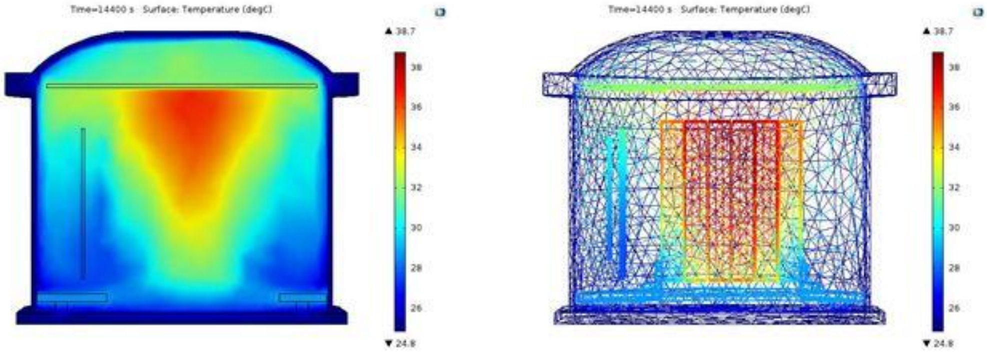

Figure 3: Thermal Simulation Results (Left: Surface View, Right: Wireframe View)