Computational Optimization of Battery Grid for Efficiency and Performance Improvement

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Abstract

Battery grids are a critical system used in automobile, renewable energy, medical devices and mobile phones. Research efforts are directed to increase energy density, longevity and reduce the cost. Batteries are classified based on the electrochemistry. Primary Disposable Batteries type includes, Zinc carbon, zinc chloride, Lithium, Silver, mercury oxide and Zinc air. The Secondary Rechargeable Batteries includes, Nickel cadmium, Nickel metal hydride, Alkaline, Lithium ion, Lithium ion polymer and Lead acid. Lead Acid battery, though a two hundred years old technology, is the workhorse of the industry. This paper is related to computational optimisation of lead acid battery for efficiency and performance improvement.

Battery grid is the precursor for the active material and current distribution in lead acid electrochemical cell. Battery grid are made by casting or expanded metal process. Configuration of the grid is critical for minimising ohmic drop, uniform current distribution and for more reaction sites.

The governing transport mechanism for the electrochemistry of lead-acid battery is due to migration, diffusion and convection molar flux of charged species (j) and for this simulation COMSOL Multiphysics® Battery and Fuel Cell Module is leveraged. The battery grid performance is governed by ionic transport mechanism and hence the Primary Current Distribution interface is used. The positive grid was used for the optimisation with the electrode, electrolyte and porous electrode. The volume fraction of the electrode, current density, electrode potential and total power dissipation density are monitored for performance comparison.

The electrode current density simulation results of the standard rectangular and the optimised grid configurations, are shown in figure 1 and 2, respectively. The optimised grid configuration shows 57% reduction in current density. Similarly, 81% reduction in Total Power Dissipation density is observed for optimised grid configuration. The paper will show, formulation, modelling method, assumptions, input boundary conditions, additional results and discussion related to industrial implementation.

These investigations highlight the potential of computational electromagnetics and electrochemistry simulations for innovative battery design.

Figures used in the abstract

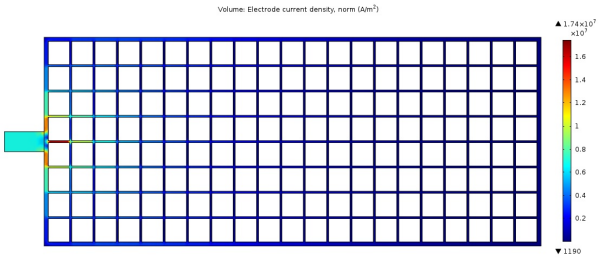

Figure 1: Electrode Current Density Contour Plots of Standard Battery Grid.

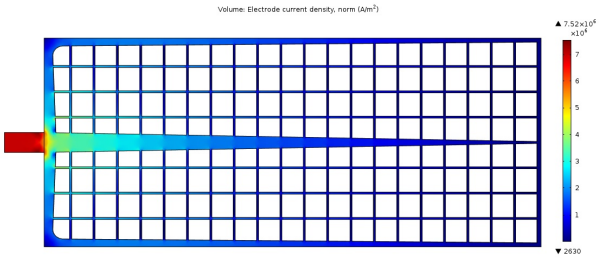

Figure 2: Electrode Current Density Contour Plots of Standard Battery Grid.