Computational Optimization of Battery Grid for Efficiency and Performance Improvement

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Introduction: Lead Acid battery, though a two hundred years old technology, is the workhorse of the industry. 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.

CEM Formulation: 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 battery and fuel cell module is leveraged. For the grid design, the Laplace eqs can be used to model ionic transport performance. Appropriate Electrode equilibrium potential is used. COMSOL Primary Current Distribution interface for the battery is used for the CEM simulations.

$$N_j = -z_j \mu_j F C_j \nabla \emptyset - D_j \nabla C_j + C_j v$$

$$\nabla_i = \sigma \nabla^2 \emptyset$$

$$\nabla^2 \emptyset = 0$$

$$\eta = E - E_e - \emptyset$$

Boundary conditions: A discharge current of 100 A is applied to the end of the lug. The primary current condition, relating the electrolyte and electrode potentials is set to the equilibrium potential of 1.7 V

Results: 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.

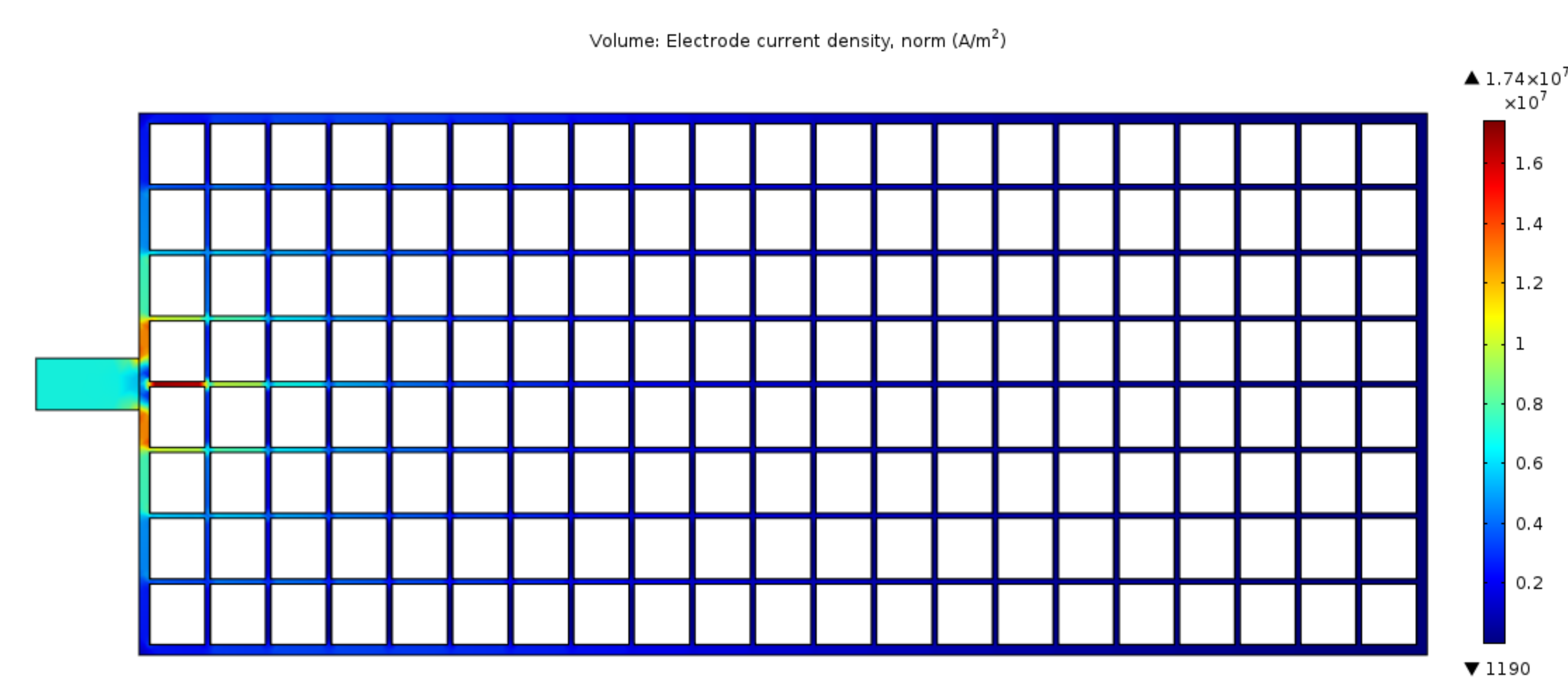

Figure 1. The electrode current density of standard battery grid

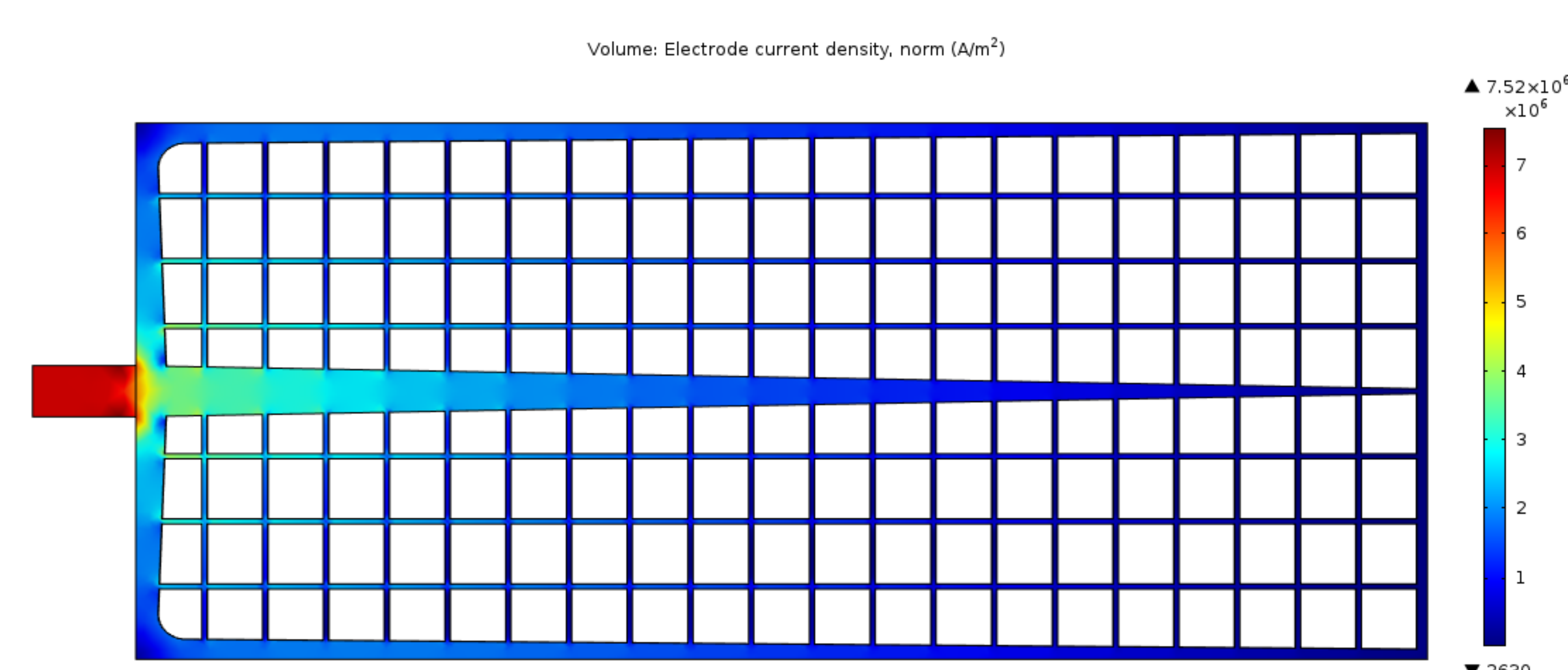

Figure 2. The electrode current density of standard battery grid

Conclusions: The computational electromagnetics (CEM) formulation, battery perforamnce modelling method, assumptions, input boundary conditions, additional results are detailed. Industrial implementation of CEM for Battery performance is the key objective of this work. These investigations highlight the potential of CEM and electrochemistry simulations for innovative battery design.

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