A Generalized Reduced Fluid Dynamic Model for Flow Fields and Electrodes in Redox Flow Batteries

Ziqiang Cheng[1], Kevin Tenny[2], Alberto Pizzolato[1], Antoni Forner-Cuenca[3], Vittorio Verda[1], Yet-Ming Chiang[2], Fikile Brushett[2], and Reza Behrou[4]

[1]Politecnico di Torino
[2]Massachusetts Institute of Technology
[3]Eindhoven University of Technology
[4]University of California San Diego

August 7, 2021

Abstract

High dimensional models typically require a large computational overhead for multiphysics applications, which hamper their use for broad-sweeping domain interrogation. Herein, we develop a modeling framework to capture the through-plane fluid dynamic response of electrodes and flow fields in a redox flow cell, generating a computationally inexpensive two-dimensional (2D) model. We leverage a depth averaging approach that also accounts for variations in out-of-plane fluid motion and departures from Darcy's law that arise from averaging across three-dimensions (3D). Our Resulting depth-averaged 2D model successfully predict the fluid dynamic response of arbitrary in-plane flow field geometries, with discrepancies of $< 5\%$ for both maximum velocity and pressure drop. This corresponds to reduced computational expense, as compared to 3D representations ($< 1\%$ of duration and 10% of RAM usage), providing a platform to screen and optimize a diverse set of cell geometries.

Hosted file

`Manu.pdf` available at https://authorea.com/users/429529/articles/533213-a-generalized-reduced-fluid-dynamic-model-for-flow-fields-and-electrodes-in-redox-flow-batteries