

Fluid Flow Patterns And Limiting Current Densities In Vanadium Redox Flow Batteries

Thorsten Struckmann¹, Jan Boettcher¹, Peter Kuhn¹, Simon Ressel¹

¹HAW Hamburg, Dept. of Mechanical Engineering, Germany

Abstract

The all vanadium redox flow battery (VRFB) is a promising electrochemical energy storage technology with the potential to play an important role in future power grids [1]. While the common VRFB cell design is planar, a tubular cell design might display advantages as reduced sealing lengths and reduced manufacturing costs due to an extrusion production process [2]. The flow-by fluid flow approach using flow channels is reducing pressure drops and pumping losses compared to the flow-through approach, but might lead to lower limiting current densities due to low electrolyte convection in the electrodes. Based on the approach of Ke [3], we use the COMSOL Multiphysics® Batteries & Fuel Cells Module and the Free and porous Media Flow interface to investigate the effect of different fluid flow patterns in the electrodes and flow channels on the limiting current densities for flow-by VRFBs: Parallel and interdigitated flow channel setups are considered for planar and tubular cell designs. Experimental results for planar cell setups are used for the calibration of fluid flow parameters like the hydraulic permeability and compression effects as well as for the validation of the simulations.

- [1] L. F. Arenas, C. P. de Leon, F. C. Walsh, Redox flow batteries for energy storage: Their promise, achievements and challenges, *Current Opinion in Electrochemistry* 16 (2019), 117-126.
[2] S. Ressel, A. Laube, S. Fischer, A. Chica, T. Flower, T. Struckmann, Performance of a vanadium redox flow battery with tubular cell design, *J. Power Sources* 355 (2017) 199-205.
[3] X. Ke, J. M. Prah, J. I. D. Alexander, R. F. Savinell, Redox flow batteries with serpentine flow fields: Distributions of electrolyte flow reactant penetration into the porous carbon electrodes and effects on performance, *Journal of Power Sources* 384 (2018) 295-312.

Figures used in the abstract

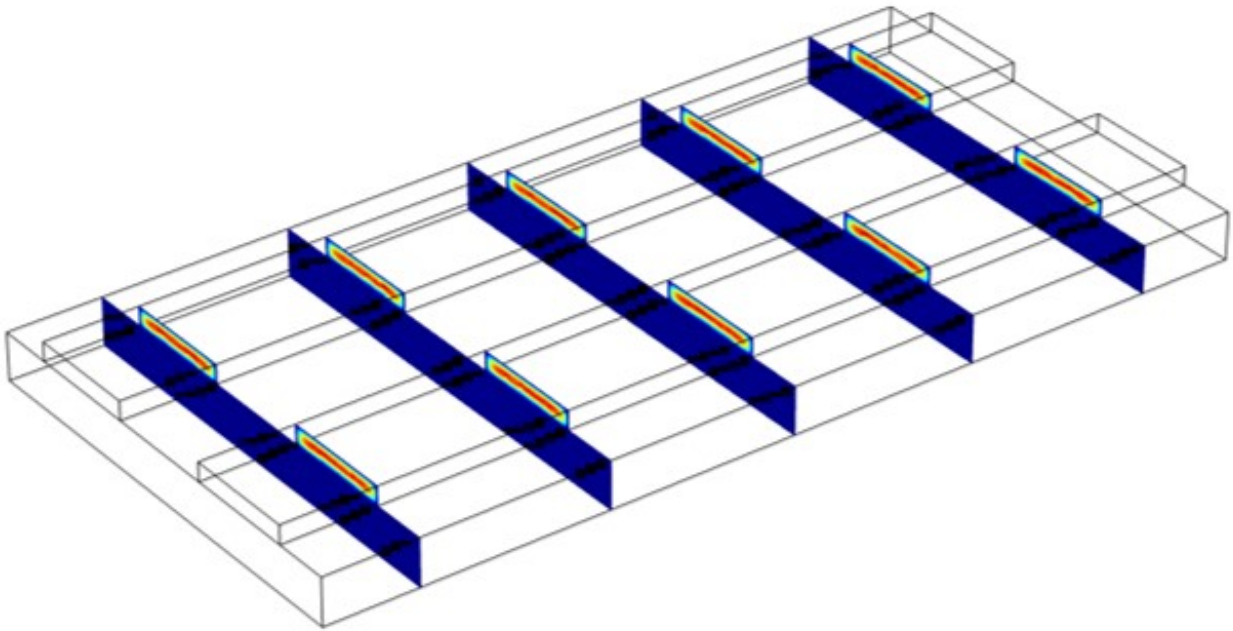


Figure 1 : Fluid Flow in Electrode with parallel Flow Channels

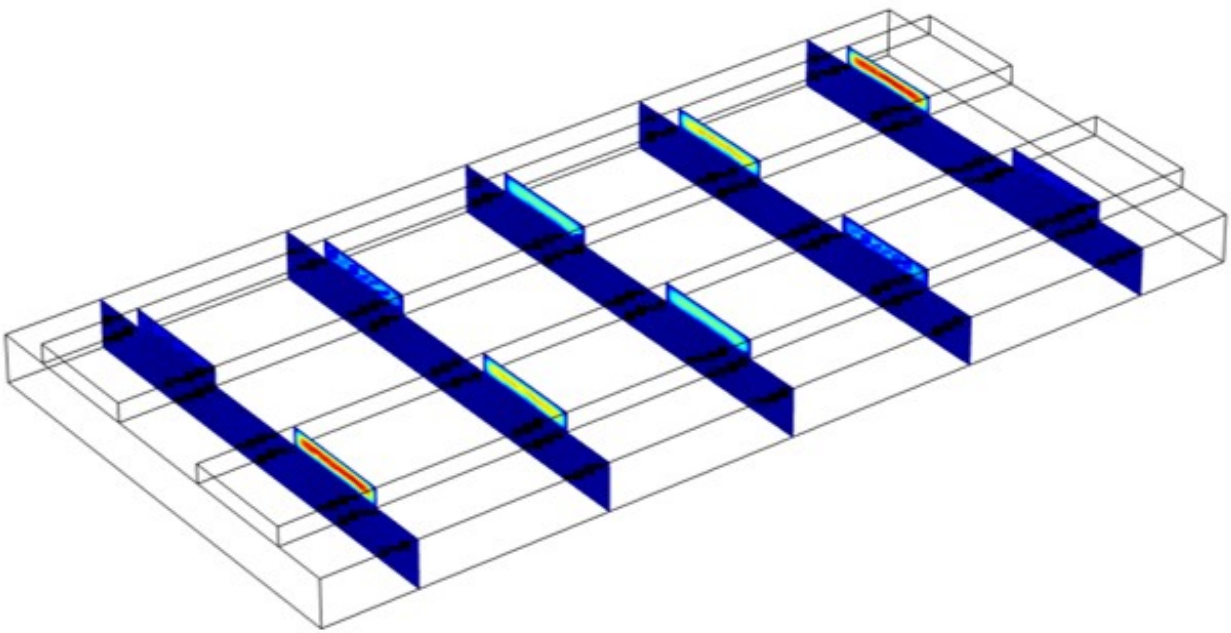


Figure 2 : Fluid Flow in Electrode with interdigitated Flow Channels