Numerical study of vanadium redox flow battery designed with and without flow fields

Qiong Wang, Zhiyuan Jiang, Dongli Lu, Zhiguo Qu*
The College of Energy & Power Engineering, Xi'an Jiaotong University, No. 28 Xianning road, Xi'an, 710049, China

Introduction: A 3D model of a vanadium redox flow battery (VRFB) with interdigitated flow channel design is proposed to study the distributions of fluid pressure, electric potential, current density and over-potential during operation. The performance of a VRFB with and without flow fields are analyzed.

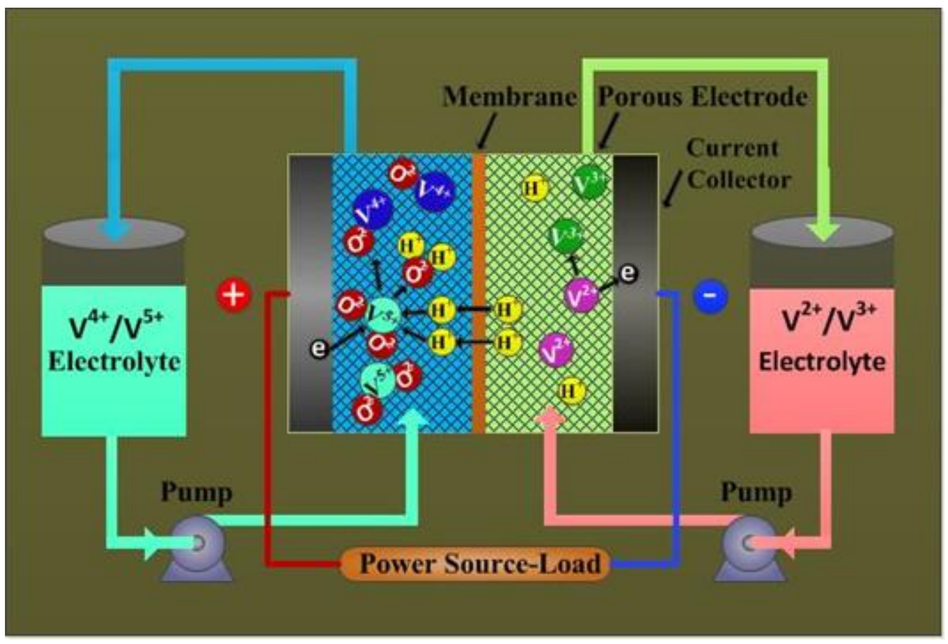

Figure 1 The schematic diagram of vanadium redox flow battery.

Numerical Methods: The main objective of this study is to solve the transport problem and the reaction kinetics, together with initial-boundary conditions and the underlying assumptions. Equations of the presented model are solved with COMSOL Multiphysics® software using finite-element method. The flow and the mass transport are modeled using reacting flow-concentrated species interface. The reaction is modeled as an electrolyte-electrode interface coupling.

Results:

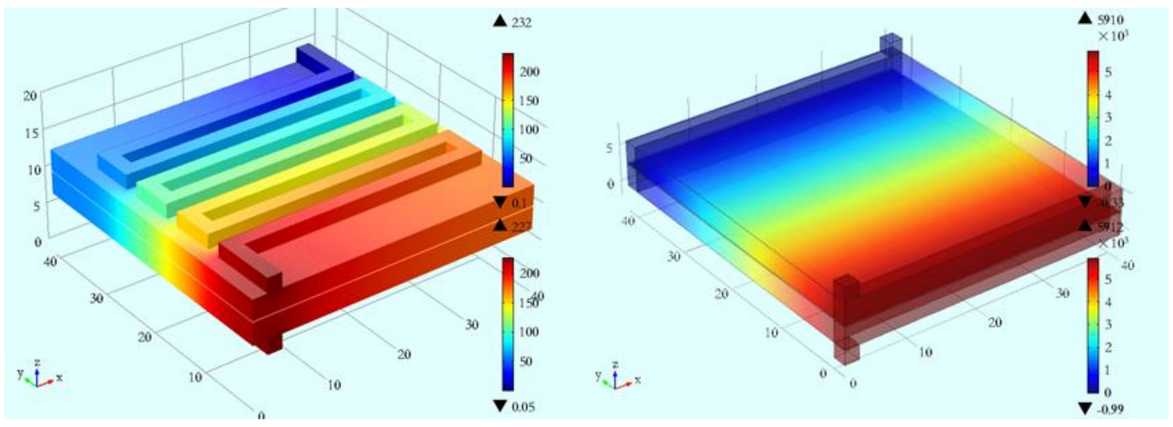

Figure 2 The pressure distribution in the electrolyte transportation domain with and without flow field (Re=105.67). (a) serpentine flow field, (b) without flow field.

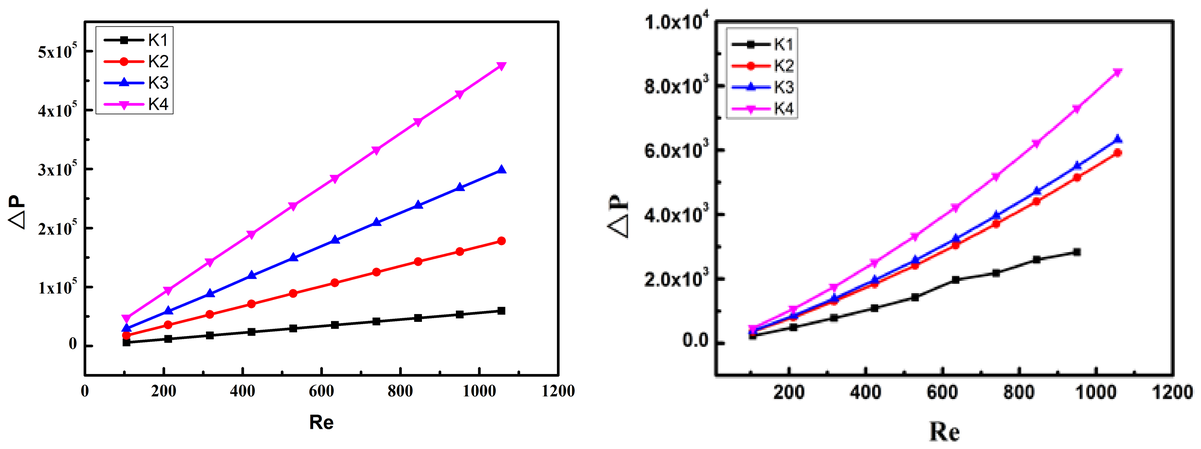

Figure 3 The pressure drop between the inlet and outlet with and without flow field at different permeability as the function of Re numbers. (a) serpentine flow field, (b) without flow field.

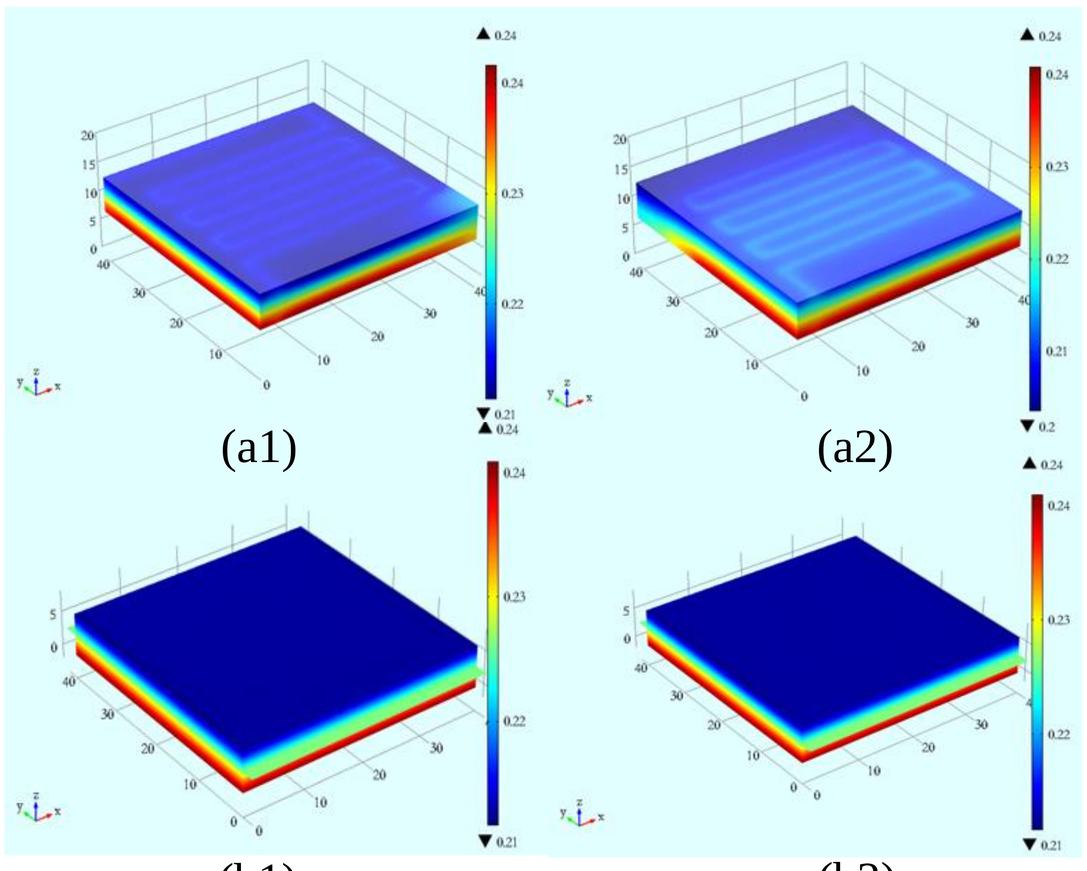

Figure 4 The potential of electrolyte with and without flow field at Re=105.67(1), Re=528.24 (2), (a) serpentine flow field, (b) without flow field.

Conclusion: The model developed in this paper can be employed to optimize both VRFB stack design and system operation conditions. Further improvements of the model concerning current density and electrode properties will also suggest in the following work.

Reference:

1. Al-Fetlawi, H., A. A. Shah and F. C. Walsh (2009). "Non-isothermal modelling of the all-vanadium redox flow battery." Electrochimica Acta **55**(1): 78-89.
2. Bromberger, K., J. Kaunert and T. Smolinka (2014). "A Model for All-Vanadium Redox Flow Batteries: Introducing Electrode-Compression Effects on Voltage Losses and Hydraulics." Energy Technology **2**(1): 64-76.