Numerical Study of Vanadium Redox Flow Battery Designed with and Without Flow Fields

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Abstract

A 3D (three-dimensional) 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 were analyzed. Figure 1 shows the schematic diagram of vanadium redox flow battery. The main objective of this study is to solve the transport problem and the reaction kinetics, togethere with intial-boudary conditions and the uderlying assumptions. Equations of the presented model were solved with the COMSOL Multiphysics® package 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. Figure 2 shows the pressure distribution in the electrolyte transprotation domain with and without flow field. (a) serpentine flow field, (b) without flow field. Figure 3 shows the pressure drop between the inlet and outlet with and without flow field at different permeability as the function of Re numbers. The pressure drop are increase with the Re numbers and permibility of electrode materials. The potential of electrolyte is obviously increase when the Re increace from 105.67 to 528.24. Figure 4 indicate that the electrolyte flow rate is the critical factors affecting flow distribution and cell performance. 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 suggeste in the following work.

Figures used in the abstract

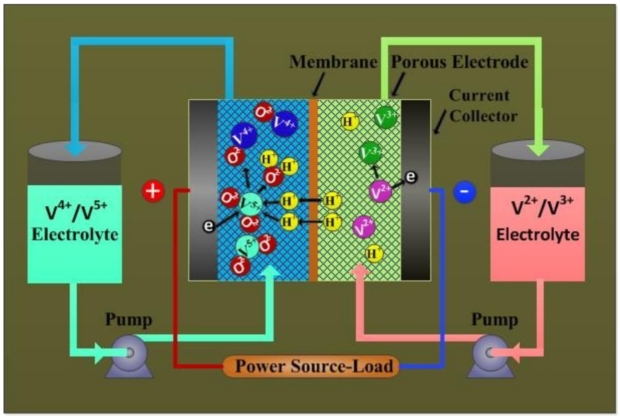

Figure 1: Figure 1 The schematic diagram of vanadium redox flow battery.

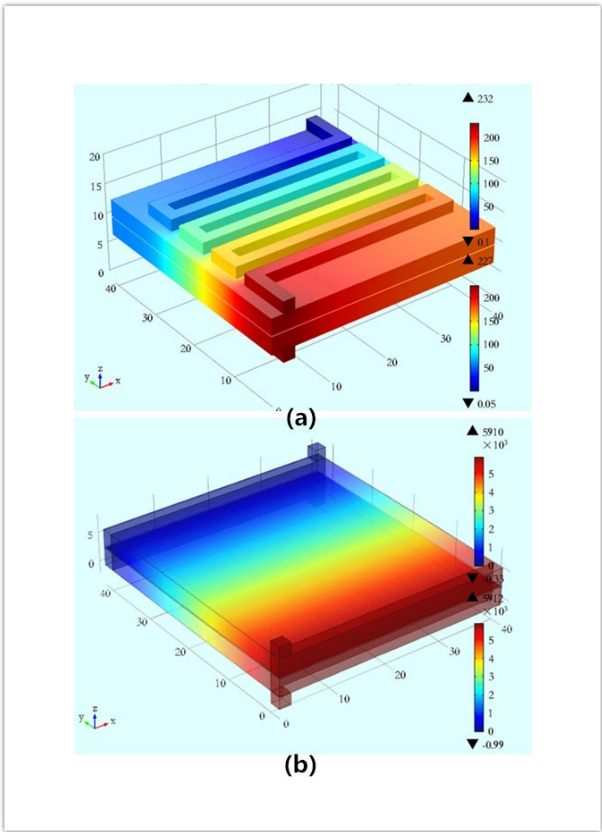

Figure 2: Figure 2 The pressure distribution in the electrolyte transprotation domain with and without flow field (Re=105.67). (a) serpentine flow field, (b) without flow field.

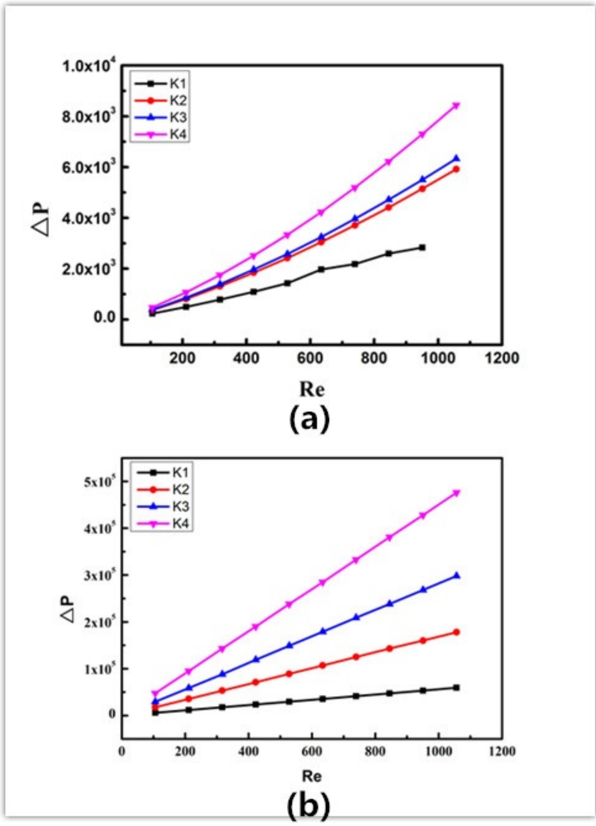

Figure 3: Figure 3 The pressure drop between the inlet and outlet with and without flow field at different permeability as the function of Re numbers. (a) serpentine flow field, (b) without flow field.

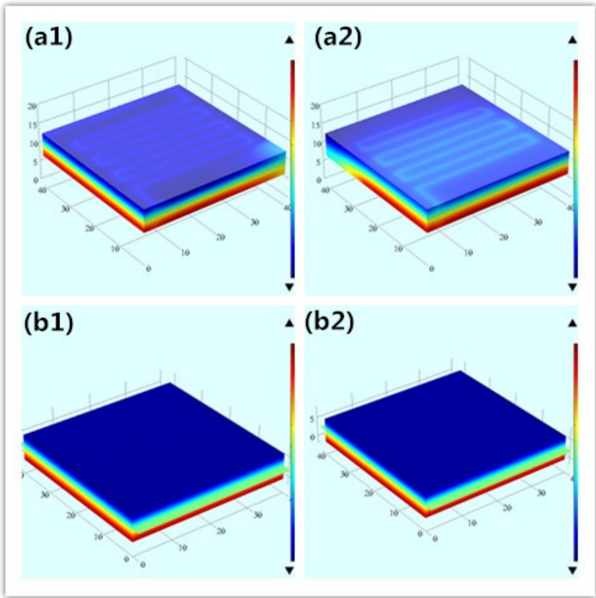

Figure 4: Figure 4 The potential of electrolyte with and without flow field at Re=105.67(1)，Re=528.24 (2), (a) serpentine flow field, (b) without flow field.