Study on architecture design of electroactive sites on Vanadium Redox Flow Battery (V-RFB)

Suhailah Sujali[1], *Mohd Rusllim* Mohamed[1*], *Ahmed Nurye* Oumer[2], *Azizan* Ahmad[3] and *Puiki* Leung[4]

[1]Faculty of Electrical and Electronics Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang, MYS
[2]Faculty of Mechanical Engineering, Universiti Malaysia Pahang, 26600 Pekan, Pahang, MYS
[3]School of Chemical Sciences and Food Technology, Universiti Kebangsaan Malaysia 43600 Bangi, Selangor, MYS
[4]Department of Materials, University of Oxford, Oxford, OX1 3PH, UK

Abstract. Numerous researches have been conducted to look for better design of cell architecture of redox flow battery. This effort is to improve the performance of the battery with respect to further improves of mass transport and flow distribution of electroactive electrolytes within the cell. This paper evaluates pressure drop and flow distribution of the electroactive electrolyte in three different electrode configurations of vanadium redox flow battery (V-RFB) cell, namely square-, rhombus- and circular-cell designs. The fluid flow of the above-mentioned three electrode design configurations are evaluated under three different cases i.e. no flow (plain) field, parallel flow field and serpentine flow field using numerically designed three-dimensional model in Computational Fluid Dynamics (CFD) software. The cell exhibits different characteristics under different cases, which the circular cell design shows promising results for test-rig development with low pressure drop and better flow distribution of electroactive electrolytes within the cell. Suggestion for further work is highlighted.

1 Introduction

Energy storage is recognised as an important technology to work with variable and intermittent in nature of renewable power sources. Therefore, energy storage has been introduced to retain and sustain the required operational and system reliability of the power sources [1][2]

Through various energy storage technologies, vanadium redox flow battery (V-RFB) shown in Fig.1[3] offers a promise because of its unique features by providing effective and simple operation, capability of decoupling high power and energy, may operate at room temperature, fast response and recharging contenders. Furthermore it comprises an excellent chemical stability that shows an extremely long-round-trip cycle, have long discharge times, good in modular design, exhibits for highly reversible redox kinetics, enable the technology for large-scale applications with theoretically reasonable and controlled maintenance cost compared to conventional battery[1][4–7]

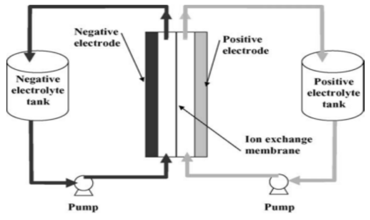

Fig. 1. Unit cell redox flow battery

As the name applies, flow battery is an electrochemical cell that produces electrical output through electrochemical reactions of two electrolytes that flow within the cell. Most of the researches in the past focused on improving poor kinetic reactions [8], conductivity [9], redox couples [10] electrodes [11] and battery characterisation [12]. A more recent works by Houser [13] *et al.* and Kumar [14] *et al.* were focusing on improving mass transport issues in redox flow battery. Mass flow is play an important role in battery to perform well [15][16]. The basic idea of study is to overcome the mass transport polarization issues and outcomes by introducing new design channel that may distribute the electrolyte well with reasonable pumping energy required. Recently, researchers systematically discuss about the electrode porous (electroactive sites) that acts as key in V-RFB systems[11][17][18].

In the conventional flow field of porous electrode, the electrolyte is directly pumped through the electroactive sites electrodes. This may results in unevenly distributed flow within the cell because the electrolyte flow through random pores of the electroactive sites part. This may causes pressure drop arising together with flow direction and this lead to a mass transfer losses and deterioration problems when the electrolyte flow into the electrode just from one lateral side. Previous researchers [19][20] have explored on creating new and appropriate flow channel for control the electrolyte flow and directly gives a positive feedback on improvement of V-RFB performance. There

* Corresponding author: rusllim@ump.edu.my