Modeling of a Vanadium Redox Flow Battery for Energy Storage

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Background

With the fast development of renewable energy, energy storage is being seriously considered as one of the key technologies. The use of energy storage technology to smooth the power generated from renewable energy, such as, photovoltaic[1], wind turbine, and so on. Vanadium redox flow battery shows promising characteristics for energy storage due to low cost and long life cycles. System energy storage capacity and output power can be designed independently. The energy storage capacity can be increased by increasing the electrolyte volume and the system output power can be increased by increasing the stack size. Shah et al. [2] proposed a comprehensive 2-D dynamic VRB model to calculate the current and potential distribution inside a 2-D cell. A simplified model was proposed by You, Zhang, and Chen [3]. The heat transfer behavior within the VRB cell was considered to account the precipitation of V ions at elevated temperature [4]. V ion crossover the membrane was also modeled by Skyllas-Kazacos et al [5] and by Knehr and Kumbur [6].

Approaches

The mode uses LabView, an commercial software developed by National Instruments, to simulate the behavior of a vanadium redox flow battery during charge and discharge process. LabView software uses built-in software functions which constitute the calculation procedure of the voltage of vanadium redox flow battery. This model uses several controlling parameters to adjust the vanadium redox flow battery operation. These parameters are: the charge and discharge current, the battery internal resistance, vanadium ion concentration, and electrolyte volume, etc.

Results and discussions

Figure 1a is the LabView interface where the controlling parameter of vanadium redox flow battery can be adjusted. Sliders, knobs, and buttons for all the adjustable parameters are given on Fig. 1a. Figure 1b is the block diagram of LabView model. One block procedure calculates the cell voltage during charge and the other block procedure calculates the cell voltage during discharge. Figure 2a is the battery voltage variation during charge and discharge at different internal resistances. The overall energy storage efficiency is decreased as the battery internal resistance increased. Figure 2b is the plot of battery voltage with different volume of electrolyte storage. The energy storage capacity is increased as the electrolyte volume increased.

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Figure 1: (a) The parameter controlling panel of vanadium redox flow battery. (b) The block diagram of vanadium redox flow battery system model.

Figure 2: (a) Change the internal resistance of the battery. (b) Change the electrolyte volume.

References