EFFECTS OF OPERATING PARAMETERS ON THE SINGLE-CELL PERFORMANCE OF THE VANADIUM REDOX FLOW BATTERY FOR ENERGY STORAGE

Chun-Hsing Wu, Hsin-Yi Liao, Kan-Lin Hsueh, and WenChen Chang

Green Energy and Environmental Research Laboratories (GEL),
Industrial Technology Research Institute (ITRI), Chutung, Hsinchu, Taiwan

Keywords: energy storage, vanadium redox flow battery, electrode material characterization

The electrical power grid is in urgent need of a new energy storage technology. This is because power generated from renewable energy, such as wind turbine and photovoltaic, is steadily increasing and the use of electric vehicles is growing rapidly. There are several available electricity storage technologies, namely hydro-pump, compressed air energy storage (CAES), and secondary batteries. The hydro-pump is the most mature, conventional storage for electrical energy; however, it is limited by geographical and environmental issues. CAES faces the same dilemmas as the hydro-pump. At present, several secondary batteries are attractive as the energy storage for photovoltaic and wind turbine system. They are lead-acid, lithium, metal hydride, sodium-sulfur, and redox flow batteries [1,2]. The redox flow battery is a good candidate for large-scale energy storage. Many test sites in the range from kW to MW were successfully demonstrated. The redox flow battery [3], especially the vanadium redox flow battery (VRB), is a promising energy storage technology because of its operation at ambient temperature, low cost, and long life cycle.

The current VRB system uses sulfuric acid at concentration around 2 M, and vanadium concentration of 1 to 3 M. The charge/discharge current density is around 40 to 80 mA cm^{-2}. A new electrolyte with a less corrosive, high vanadium concentration and fast reaction rate is beneficial for a better VRB energy storage system. For less corrosive electrolyte, more choices of low-cost material can be used for safe operation and maintenance. For a fast reaction rate, the energy storage can be operated at high charging/discharging current. It also reduces the cell stack volume. Electrolyte with high vanadium concentration improves the energy density of the entire storage system.

The purpose of this work is to study various operating parameters on the performance of a single cell. Those parameters are electrode compression pressure, electrode surface pretreatment, electrode configuration, electrode catalyst, and electrolyte composition. The cell performance is evaluated by the cell voltage versus current (E-I) curve.

Electrolyte used in the single-cell study is 2.0 M $VOSO_4$ + 2.0 M H_2SO_4 aqueous solution. This study used a conventional single cell for proton exchange membrane fuel cell testing. This cell has an electrode active area of 25 cm^2 (5 cm × 5 cm) with serpentine flow channels. A hydraulic press was used for the electrode compression experiment. Nafion 117 (from du Pont) was used as the separator of single cell.

We investigated the effects of operating parameters on the single-cell performance (cell voltage versus current). In order to reduce the resistance to acceptable level, carbon felt needs a higher compression pressure than the carbon paper. The porous layer of the electrode adjacent to the membrane has better performance than that facing the flow channel. An electrode coated with catalyst improves cell performance. Electrolyte containing a high concentration of vanadyl ion is a significant improvement over electrolyte with low vanadyl ion (VO^{+2}). However, concentrated electrolyte (4.0 M $VOSO_4$) is not stable at a high current operating condition.

During this study, we designed and fabricated a new prototype single cell. Cell configuration is given in Figure 1. A short stack containing five cells was also built. Both the single cell and short stack will be tested and revised in the near future.

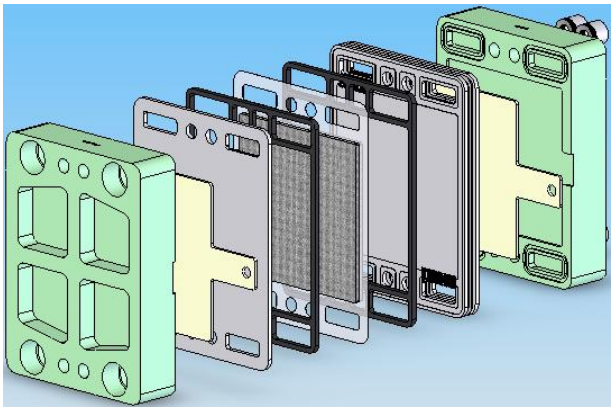

Fig. 1. Configuration of a prototype single cell.

ACKNOWLEDGMENT

This work is carried out with financial support from the National Science Council (NSC) under contract number 97-2623-7-239-001-ET and 98-2623-E-239-001-ET. Experimental work was carried out by Ms. Hsin-Yi Liao as her M.S. Thesis, Department of Chemical Engineering, National United University. The authors wish to thank the technical assistant from Industrial Technology Research Institute/Green Energy and Environment Research Laboratories (ITRI/GEL). Part of this work will be published in *Electrochemical Society Transaction 2011*.

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BIOGRAPHICAL NOTE

Conference presenter: Dr. Chun-Hsin Wu is a researcher of the Green Energy and Environmental Lab (GEL) in the Industrial Technology Research Institute (ITRI). His graduate research was focused on the reaction kinetic study on organic waste decomposition by a titanium dioxide photo-catalyst. After he obtained his Ph.D. in 2006, he joined the hydrogen and fuel cell research team of GEL and worked on catalytic reforming of natural gas, fabrication of electrodes, and development of metal bipolar plates. Since 2009, he was in charge as the project coordinator of large-scale energy storage, including metal-air batteries and redox flow batteries for grid-scale energy storage. Dr. Wu has 4 patents and 17 papers published in conferences and journals.