

Performance Assessment of Solid Oxide Cells for Electrical Energy Storage

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Electrical energy storage (EES) is expected to be an important component of the future energy grid, particularly for integrating intermittent renewable energy sources. Some of the key parameters for successful implementation of energy storage devices are related to cost, efficiency, storage capacity, and widespread availability. The currently available EES technologies all generally fail to meet at least one of these metrics; for example, conventional batteries alone are not appropriate for long-term energy storage because of their low energy density. Some recent studies demonstrate that an EES system based on reversible solid oxide cell (rSOC) technology offers a potentially high efficiency, low cost, and scalable distributed energy resource¹. Fig. 1 shows an example of a novel EES system which is based on H-C-O chemistry using high temperature rSOCs. Such a system involves a solid-oxide cell stack that is cyclically operated in both power-producing fuel cell mode and fuel-producing electrolysis mode.

Modeling rSOC-based energy storage systems is an optimum way to elucidate attractive system architectures that enable one to effectively retain the high efficiency of the rSOC stack. A critical step in developing system models is to have a high fidelity cell- and stack-level model that can be employed to predict the rSOC performance in both modes of operations. Thus, a mathematical model based on the mass, momentum, and energy conservation laws is developed in this study. The model also involves a complete analysis of the cell electrochemical losses as well as the global reaction rates for water gas shift (WGS) (or reversible WGS) and steam reforming (or methanation) reactions. The model is calibrated and validated versus experimental data for a fuel-electrode supported cell. The model is then employed to explore the influence of various factors that affect the rSOC performance and roundtrip storage efficiency. The results reveal that increasing the rSOC operating pressure can considerably decrease the cell electrochemical losses (concentration and activation losses) in both operational modes. It is also shown that reducing the cell operating temperature may promote the methanation reaction rate considerably at higher pressure; although the cell electrochemical losses (ohmic, and activation) can increase in this condition.

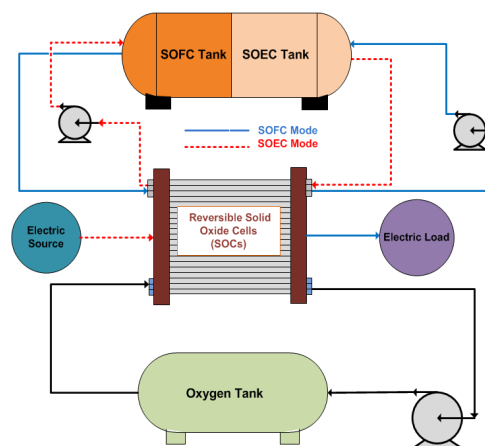


Fig. 1- Reversible Solid Oxide Cell System

1- D.M. Bierschenk, J.R. Wilson, S.A. Barnett, *Energ. Env. Sci.*, 4 (2011) 944-951.