R & D facts

U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

Fuel Cells

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Solid Oxide Fuel Cells For Coal-Based Power

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Background

The Solid State Energy Conversion Alliance (SECA) program will provide the technology for future coal-based fuel cell power plants, as shown in Figure 1—a concept of a FutureGen plant that supports an efficient and clean hydrogen and electric economy. Before this technology can be achieved, however, improved understanding of how SECA technology will perform under coal syngas is needed. This project performs research that identifies the effects of coal contaminants on fuel cell operation.

The specific objectives for this project are as follows:

Figure 1. Future Gen

- Test solid oxide fuel cells (SOFC) button cells on simulated coal syngas to generate performance data and model validation data
- Test current SOFC technology for the effects of syngas trace species
- Develop models specific to anode transport of coal syngas
- Evaluate the effect of pressure on cell performance (efficiency and degradation)
- Investigate methods to mitigate coal contaminant gas effects
- Test SOFC cells directly on gasified coal to assess the performance of today's SOFC technology

NETL Onsite Research

Researchers at the National Energy Technology Laboratory (NETL) recently analyzed the transport of syngas within the anode of an SOFC to characterize their performance for these future systems, paying particular interest to identifying the effect of pressure on SOFC anode performance. Of note is the effect of pressure on the water gas shift (WGS) and methane steam reforming (MSR) kinetics. Figure 2 shows results of model predictions for net heating/cooling of the anode due to the WGS and MSR reactions. The results suggest that these reactions may cause significant extra heating of the cell inlet edge. This same transport model is also used to predict the behavior of contaminates (non-reacted with anode material). Figure 3 shows results for arsenine and indicates that the level of arsenine near the electrolyte interface will likely fall as load is increased. These types of results are helpful to guide the interpretation of experimental results discussed in the next paragraph.

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Researchers at NETL are also conducting experimental tests to determine the effect of specific coal contaminants on the performance of an SOFC cell. Figure 4 shows a photo of a test rig that is used for these tests. The setup employs permeation tubes that contain a specific contaminate with known evaporation rates. Present tests on arsenine show that it is possible for arsenine to strongly degrade the cell (Figure 5). Further testing will be done to confirm these results and to test other contaminant materials.

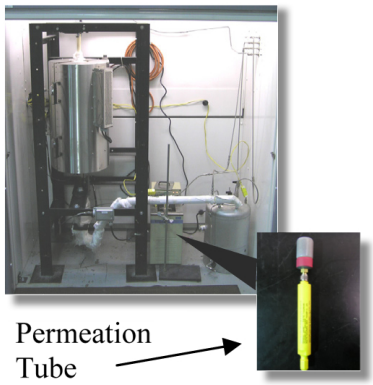

Figure 4. Test rig

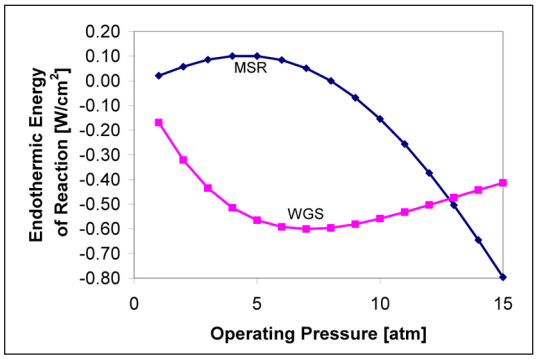

Figure 2. Overall anode cooling due to WGS and MSR reactions (negative values indicate overall heating).

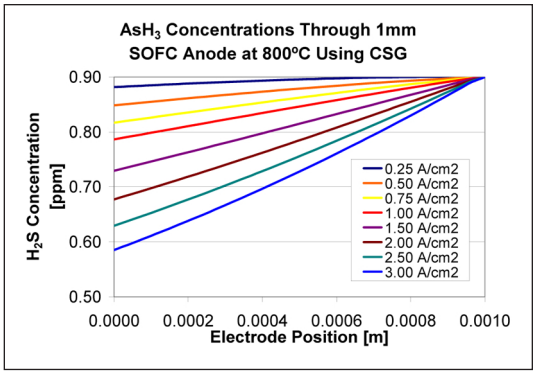

Figure 3. Effect of cell operation on the transport of arsenine coal contaminant.

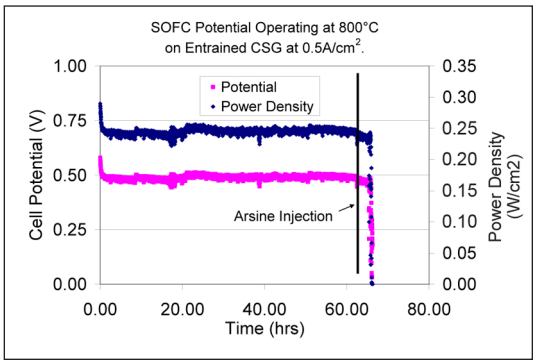

Figure 5. Effect of arsenine on cell performance.

Opportunities

These experimental facilities are used in collaboration with West Virginia University (WVU), University of Pittsburgh (Pitt), and Carnegie Mellon University (CMU) to expand and speed NETL work in SOFC fuel cells. Work includes studying the effect of coal syngas on interconnect materials (Prof. Mao/Pitt, PI), determining the effect of current collection geometry on cell materials (Prof. Salvador/CMU, PI), and developing new diagnostic methods for material analysis (Prof. Halliburton/WVU, PI). NETL continually seeks collaborators that are interested in advancing SOFC technology for coal-based power applications.