V.A.8 Fuel Cell Testing at Argonne National Laboratory

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Start Date: 1996
Projected End Date: Project continuation and direction determined annually by DOE

Objectives

- Provide DOE with an independent assessment of the performance of fuel cell systems and components developed under DOE contracts.
- Characterize and benchmark the performance of state-of-the-art commercial fuel cell technology available in the market.

Technical Barriers

This project addresses the following technical barriers from the Fuel Cells section 3.4.4 of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

(A) Durability
(C) Performance
(D) Water Transport within the Stack
(G) Start-up and Shut-down Time and Energy/Transient Operation

Contribution to Achievement of DOE Fuel Cells Milestones

This project will contribute to achievement of the following DOE milestones from the Fuel Cells section of the Hydrogen, Fuel Cells, and Infrastructure Technologies Program Multi-Year Research, Development, and Demonstration Plan:

- **Milestone 86:** Evaluate short stack against 2011 targets for operation over the full operating temperature range. (4Q, 2010)
  We are testing stacks from different developers and documenting their performance according to well-defined test protocols for comparison of the measured performance against DOE targets.
- **Milestone 87:** Test and evaluate fuel cell systems and components such as MEAs, short stacks, bipolar plates, catalysts, membranes, etc., and compare to targets. (1Q, 2011)
  We are testing fuel cell stacks, balance-of-plant components, and complete systems to document their performance for comparison to DOE targets.
- **Milestone 88:** Test and evaluate fuel cell systems and components such as MEAs, short stacks, bipolar plates, catalysts, membranes, etc., and compare to targets. (4Q, 2015)
  We are testing fuel cell stacks, balance-of-plant components, and complete systems to document their performance for comparison to DOE targets.

Accomplishments

- Characterized a 1-kW stack for sensitivity to operating conditions. The maximum power the stack developed was 1,332 W at ambient pressure, achieving a thermodynamic efficiency of 53.8%. At 25% of rated power, the efficiency increased to 65.6%.
- Characterized two 5-kW complete systems.
- Participated in and made technical presentations at the second meeting of the International Organization for Standardization Working Group 11 under Technical Committee 105 of the International Electrotechnical Commission, held on December 17-18, 2007, in Frankfurt am Main, Germany. The goal of this international group is to draft the technical specification of a single-cell test protocol. Representatives from six countries attended.
- Upgraded the test facility by replacing the air supply subsystem to provide clean, hydrocarbon-free air to the fuel cells or systems under test.

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Introduction

This project helps DOE determine and document progress toward achieving its technical targets by providing an independent assessment of evolving fuel cell technology. In addition, in this project we develop standard fuel cell testing procedures to aid in the evaluation of different stack technologies. The procedures and methods used are transparent to the technology being tested; thus, they provide a means for easy comparison of the performance and expected life of the technology from many different developers. In these procedures, the stack is characterized in terms of initial performance, durability, and low-temperature performance. To further accelerate fuel cell technology, these procedures are compared with similar procedures developed by other national and international organizations.

The initial performance establishes a baseline for comparison as the fuel cell ages. The aging process is accelerated to yield a reasonable projection of life at constant power and under driving duty cycles in a reasonable amount of testing time. Periodically during the aging test, the test is interrupted and the stack performance is characterized. A life projection is then made by comparing the most recent performance characteristics with those measured earlier.

Approach

We have developed standardized fuel cell and stack test procedures to aid in the evaluation of different stack technologies. These test procedures characterize the stack in terms of initial performance (e.g., power and voltage vs. current, hydrogen cross-over), durability, and low-temperature performance.

The test facility is flexible enough to accommodate the unique needs of different technologies. Modification and upgrading of the test facility is an ongoing process that is carried out in consultation with fuel cell developers and DOE.

Results

The performance of a 1-kW, 36-cell, air-cooled, hydrogen-fueled, fuel cell stack was characterized. The stack performance was investigated under the different operating conditions, including stack temperature, humidification (dew point temperature) of feed gases, and reactant gas stoichiometry. The stack displayed very little, if any, sensitivity to fuel stoichiometry down to 1.3. However, the stack displayed significant sensitivities to operating temperature, feed hydrogen dew point temperature and air stoichiometry. As expected, for each of these operating parameters, there was marked performance decline at the lowest value in the range tested.

Example polarization curves from the air stoichiometry sensitivity study are shown in Figure 1. There was a marked decrease in stack performance at 550 mA/cm^2 when the air stoichiometry was decreased from 5 to 2. Here, the stack potential decreased from 24.22 V to 23.60 A (i.e., by 620 mV), with a corresponding decrease in stack power. The stack power decreased from 1,332 W to 1,299 W with an increase in stack temperature from 67 to 70°C.

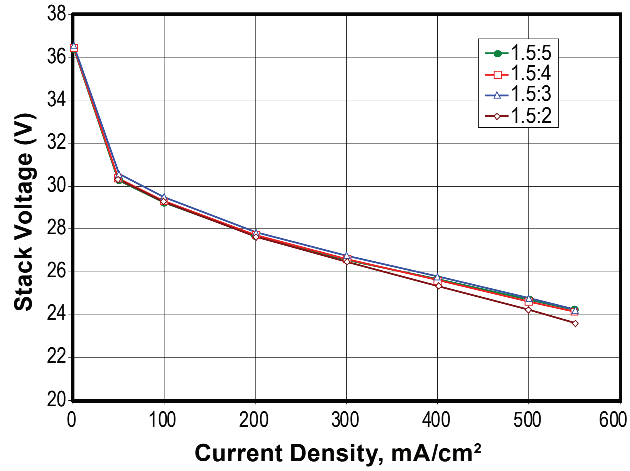

FIGURE 1. Polarization Curves from the Air Sensitivity Study

Polarization curves from the operating temperature study are shown in Figure 2. When the temperature was lowered from 65°C to 55°C, the stack output voltage decreased from 24.25 V to 23.40 V (i.e., by 850 mV) at 550 mA/cm^2. This decrease in stack potential corresponds to a drop in stack power from 1,332 to 1,289 W and a change in stack thermodynamic energy efficiency from 53.8 to 52.0%.

Increasing the operating temperature from 65°C to 75°C also decreased the performance of the stack slightly, from 24.25 V to 24.10 V (i.e., by 150 mV). Correspondingly, the stack power decreased from 1,332 W to 1,324 W, with a change in stack thermodynamic energy efficiency from 53.8 to 53.5%.

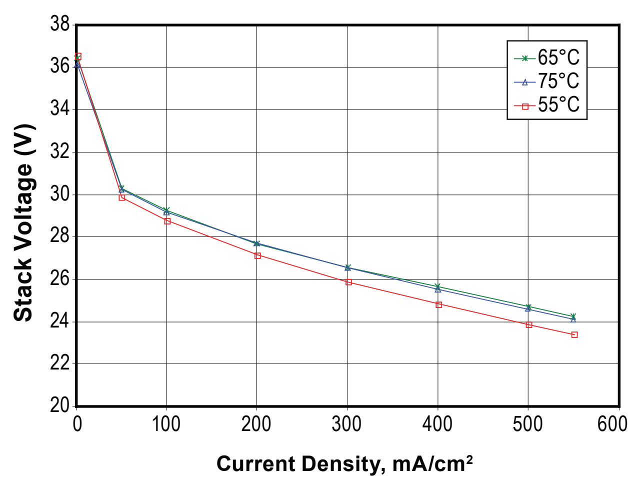

FIGURE 2. Effect of Operating Temperature on Stack Performance

Conclusions and Future Directions

- Continue to characterize DOE fuel cell contract deliverables.
- Continue to benchmark other fuel cell technologies.
- Continue to collaborate with other fuel cell testing laboratories, such as the Institute for Energy (Netherlands), and $FCTes^{QA}$.
- Continue to work with Working Group 11 to draft the technical specification for a single-cell test protocol.
- Continue to upgrade the test facility by installing two 20-kW load banks, a new data acquisition and control computer and new test hardware and software.

FY 2008 Publications/Presentations

1. Fuel Cell Testing – A Comparison of Procedures and Results, I. Bloom, L. Walker, J. Basco, Y.-Y. Yan and H.-R. Shiu, $FCTes^{QA}$ Meeting, October 15, 2007, San Antonio, TX.