V.G.7 Fuel Cell Testing

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

Objectives

- To provide DOE with an independent assessment of the performance of fuel cell systems and components developed under DOE contracts.
- To benchmark commercial fuel cell technology developments.

Technical Barriers

This project addresses the following technical barriers from the Fuel Cells section (3.4.4.2) of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan:

(A) Durability

(J) Startup Time/Transient Operation

Technical Targets

This project helps DOE document progress towards achieving its technical targets by providing independent assessment of the evolving fuel cell hardware. Additionally, the project develops standard fuel cell testing procedures to aid the evaluation of different stack technologies. In these procedures, the stack is characterized in terms of initial performance, durability and low-temperature performance (future work). 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.

In this task, we also participate in Fuel Cell Testing, Safety and Quality Assurance (FCTES^{QA}). The goal of FCTES^{QA} is to harmonize testing procedures among different countries. Harmonization will facilitate communication and understanding of results, helping to accelerate fuel cell development. For this work, head-to-head comparisons of procedures are made regarding the quality of the data obtained, ease of use of the test protocols, and reproducibility of the results by using similar test hardware and fuel cells at participating test sites.

Accomplishments

- Characterized two 7.5-kW stacks.
- Characterized reformer-only subsystem.
- Enhanced cooling system of the facility to handle 100 kW_t.
- Installed two 5-kW stacks for testing.
- Demonstrated that using pulsed currents for polarization curves gives results comparable to those obtained from constant current. Pulsed-current testing is more representative of automotive applications than steady-state, particularly at high powers. The pulse-current technique is a viable option when the stack cannot be operated under steady loads for long periods of time.

Introduction

Independent fuel cell testing provides unbiased assessments of the state of development of fuel cell technology. The procedures and methods used are transparent to the technology under test. Thus, they provide a means for easy comparison of the performance and expected life of the technology from many different developers.

Approach

Standardized fuel cell stack test procedures have to be developed to aid the evaluation of different stack technologies for potential use in automotive applications. 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. The modification of the facility is an ongoing process and is done in consultation with fuel cell developers and DOE.

Results

During our work, it was found that some fuel cell systems cannot be operated at high power for very long periods of time due to a test stand issue. To circumvent this issue, we used pulsed currents in some of the polarization experiments. A typical pulse-current profile is given in Figure 1. Here, the duration of the high-current steps ranged from 53 s to 64 s.

One important question regarding the use of pulsed currents is how the polarization results compare with those obtained under steady-state loads. Figure 2 shows the results from two polarization experiments during the testing of an 85-kW stack. At less than 0.1 A/cm^2, the constant-current curve displays higher voltages than its pulsed-current counterpart. Possible reasons for the difference include a difference in membrane humidification. The membrane under the steady-state load is better humidified than it is during the pulsed-current experiment. At higher than 0.1 A/cm^2, the two curves are practically indistinguishable.

In the automotive application, a fuel cell stack is not expected to run under steady-state load for an extended length of time. Instead, pulsed currents would be expected, particularly at high powers. Using pulsed current would give a better indication of how the fuel cell will respond to the power transients in automotive use. For example, Figure 3 shows the temperature and power response to a current pulse in an 85-kW fuel cell stack. This type of thermal transient will need to be accommodated in automotive fuel cell systems.

The European Union, Japan, and the U.S. have different procedures for testing single cells and stacks. The use of these separate procedures can yield results that may be difficult to fully understand or compare with one another. Thus, harmonizing the procedures by establishing a common glossary and testing protocols would facilitate DOE reaching its technical targets by accelerating fuel cell development. Argonne is participating in this international effort, called FCTES^{QA} (Fuel Cell Testing, Safety and Quality Assurance), by proposing a set of protocols to characterize the initial performance and the durability of a given proton exchange membrane (PEM) fuel cell technology. Under this effort, head-to-head comparisons will be made regarding the quality of the data obtained, ease of use, and reproducibility by using similar test hardware and fuel cells. The first meeting was held on May 15, 2006. The group will select protocols for further evaluation from the several that were presented at the meeting.

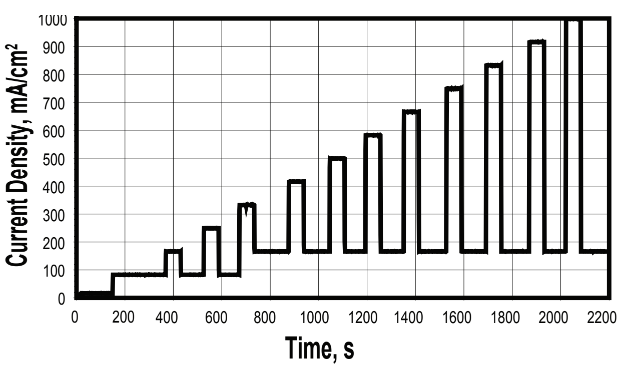

FIGURE 1. Typical pulse current profile used for a polarization experiment on an 85-kW stack. The pulses are 53 to 64 s long.

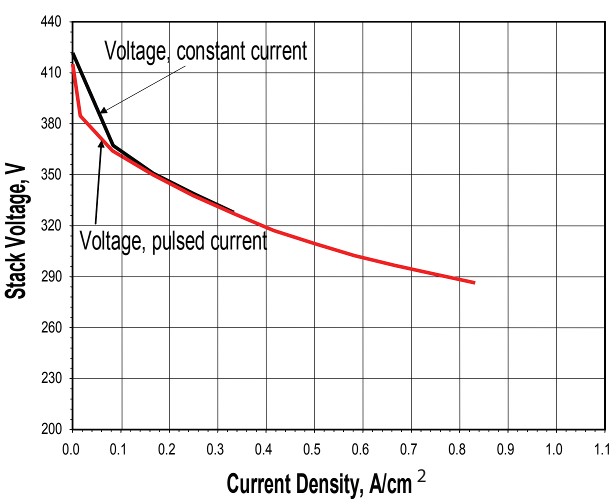

FIGURE 2. Voltage and power vs. current density curves from the steady-state and pulsed-current polarization experiments.

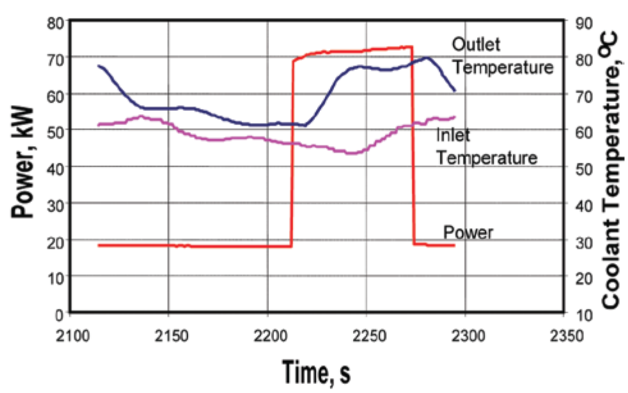

FIGURE 3. Power and temperature vs. time from a pulsed current polarization experiment.

Conclusions and Future Directions

- Pulsed-current polarization curves are a viable alternative to steady-state testing when the fuel cell stack cannot be operated at high power for long periods of time.
- 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 Los Alamos National Laboratory, and $FCTES^{QA}$.