Atmospheric Fuel Cell Power System for Transportation

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Objectives

The objectives of this project are to demonstrate, through testing, the following:

- One fully integrated, gasoline fueled 25-50 kW proton exchange membrane (PEM) power plant.
- Two-phase approach using catalytic partial oxidation (CPO) fuel processing system (FPS).
  - Phase one, Fuel Processor One (FP1): focus on start time, steady state and transient operation of the FPS and generation of quality reformate. Testing conducted in FY 2003.
  - Phase two, Power Plant One Reformate (PP1R): focus on demonstrating full integration of PEM fuel cell power plant. Testing to be conducted in FY 2004.

Technical Barriers

This project addresses the following technical barriers from the Fuel Cells section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year R,D&D Plan:

- I. Fuel Processor Start-up/Transient Operation
- J. Durability
- K. Emissions and Environmental Issues
- L. H_2 Purification/CO Cleanup
- M. Fuel Processor System Integration and Efficiency
- N. Cost

Approach

- Build FP1, integrated FPS assembly.
- Test CPO based FPS, FP1.
- Build PP1R power plant from FP1.
- Test PP1R assembly, fully integrated PEM power plant.
- Tear down and analyze PP1R test article.

Accomplishments

- Built and tested integrated fuel processing system, FP1.
- Analyzed data and presented results at the DOE annual merit review meeting.
- Started building fully integrated PEM power plant.

Future Directions

- Test PP1R assembly, fully integrated PEM power plant.
- Analyze and present PP1R test data.
- Tear down and analyze PP1R assembly.

Introduction

UTC Fuel Cells (UTCFC) is committed to the commercialization of PEM fuel cell power plants for transportation applications. UTCFC has in place a program addressing the technology development and verification of each of the necessary components, subsystems and fully integrated power plant. The focus of the program is an ambient PEM power plant operating on gasoline liquid fuel capable of delivering 25-50 kW net DC power using a CPO-based fuel processor.

Approach

Figure 1 provides a schematic of the gasoline fuel cell power plant showing the distinction between FP1 and PP1R. The major subsystems include the Fuel Processing Subsystem, the Power Subsystem and the Balance of Plant (BOP). The BOP includes the Thermal Management Subsystem, the Air and Water Subsystems and the Controller and associated electrical equipment.

A photograph of the FPS is shown in Figure 2. This is a fully assembled FPS that includes the CPO reformer, low and high temperature shift converters and CO cleanup. Figure 3 is a photograph of the FP1 assembly with the FPS integrated.

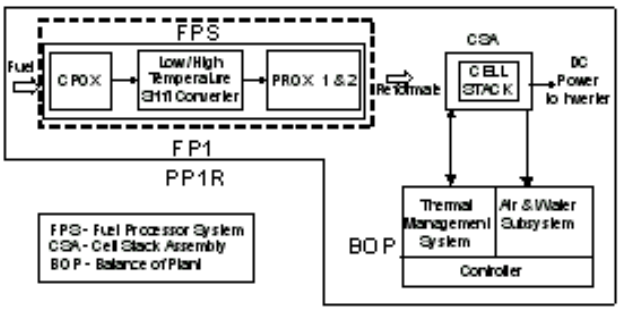

Figure 1. System Schematic

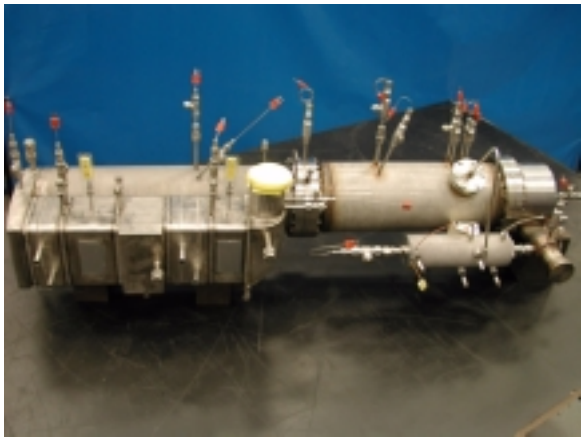

Figure 2. FPS Assembly

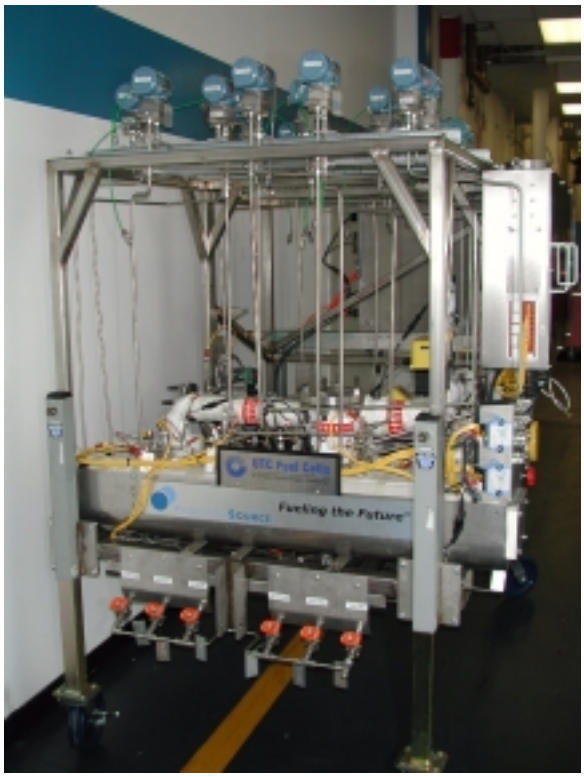

Figure 3. FP1 Assembly

Results

The FP1 test article was tested at UTCFC's facilities in South Windsor, Connecticut. The fuel used for this testing was California Phase II desulfurized reformulated gasoline (RFG) liquid fuel. Table 1 provides the FP1 test data summary compared against industry target values.

Table 1. FP1 Data Summary (LHV = lower heating value, NMHC = non-methane hydrocarbon, ppm_{vw} = parts per million by volume on a wet basis)

FP1 Summary	Target	FP1 Test Data
FPS Volume, liters	75	78
Heat up time, s	165	171
Number of start/stops	500	111
Duration of operation (total hrs) - Longest single run, hrs	2000	232 hrs 10 hrs
Range of equivalent power, kWe	10-50	10-50
LHV efficiency, % at rated LHV efficiency, % below rated	≥75 ≥70	69% 69-72%
Emissions (ppm_{vw}) - Start (NMHC, CO, NO_x) - Run (NMHC, CO, NO_x, CO_4) - Transient (CO, NH_4, Aromatics)	 <34, 1791, 21 <22, 15. 1.6, 700 <100	 5, 1.7, 9.1 20, 14, <1, 630 TBD

Figure 4 provides data that show the FPS was able to start up in approximately 5 minutes.

Figures 5 and 6 show the FP1 steady state and transient CO levels. CO levels during steady state and transient operation were in the 20 ppm range, which is the desired limit for acceptable PEM fuel cell operation. These results show that the CPO-based FPS is capable of producing reformate acceptable for PEM fuel cell operation.

Following FP1 testing, the test article was removed from the UTCFC test stand and started its build to the PP1R power plant, in preparation for phase two of testing.

Conclusions

The FP1 test results showed significant improvements over the previous generation gasoline reformate system (S200). Start time and CO levels coming out of the FPS and into the cell stack are critical areas for on-board reforming to be promising for commercial transportation applications. FP1 start time of approximately five minutes and CO levels in the 20 ppm range are very encouraging and provide a good baseline for the fully integrated power plant testing scheduled for next year.

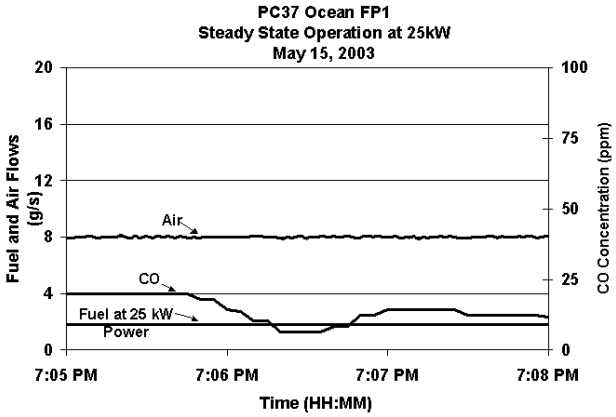

Figure 5. FP1 Steady State Data

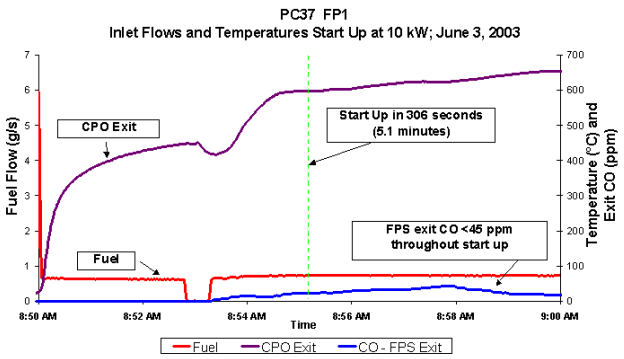

Figure 4. Start Time Demonstration

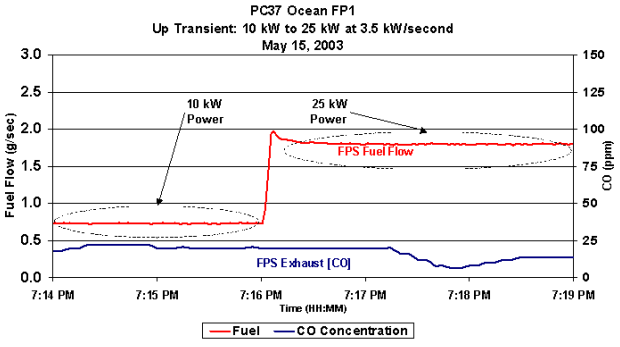

Figure 6. FP1 Transient Data

UTCFC is committed to the commercialization of PEM fuel cell power plants for transportation applications and will test the fully integrated PEM power plant (PP1R) next year along with Argonne National Laboratory (ANL).

FY 2003 Publications/Presentations

1. M. Tosca, "Atmospheric Fuel Cell Power System for Transportation", DOE Hydrogen, Fuel Cells and Infrastructure Technologies Program 2003 Annual Merit Review, Berkeley, CA (May 2003).

2. M. Steinbugler, "Progress and Challenges in PEM Automotive Fuel Cells with Gasoline Reformers", The 3rd International Advanced Automotive Battery Conference, June 10-13, 2003, Nice, France.