XII.2 Jadoo Power Fuel Cell Demonstration

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Delphi Automotive, Rochester, NY

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Objectives

- The development of two portable electrical generators in the 1,000 watt range utilizing solid oxide fuel cells (SOFCs) as the power element and liquefied petroleum gas (LPG) as the fuel.
- The development and demonstration of a proof-of-concept electromechanical LPG fuel interface that provides a user-friendly capability for managing LPG fuel.
- The deployment and use of the fuel cell portable generators to power lighting and video production equipment over the course of several months at multiple National Association for Stock Car Auto Racing (NASCAR) automobile racing events.
- The deployment and use of the fuel cell portable generators by first responders (police, fire) of the City of Folsom, California to power equipment in emergency and/or off-grid situations.
- Capturing data with regard to the systems' ability to meet DOE technical targets and evaluating the ease of use and potential barriers to further adoption of the systems.

Relevance to the American Recovery and Reinvestment Act (ARRA) of 2009 Goals

This project will create or save existing jobs and spur economic activity in California and New York. This project will demonstrate the efficacy of fuel cell generators in multiple applications that have near-term potential for commercialization and development of the fuel cell market.

Technical Barriers

- Reducing stack and balance of system to size allowing portability.
- Reliability of SOFC system under rough field conditions.
- User factors related to start-up times and refueling.
- Effectiveness/complexity of processing LPG to remove sulfur.
- Potential constraints on type or source of LPG.

Technical Targets and Milestones

- Develop LPG desufurizer - reduce the level of sulfur in LPG to less than 10 ppb for eight continuous hours.
- Develop SOFC portable generator - produce 1 kW using LPG for eight continuous hours.
- Operation of generator at minimum 30% efficiency for minimum of 2,000 cumulative hours.
- Develop a user-friendly electromechanical LPG fuel interface — indicate the amount of LPG within ± 10% of the actual amount for the entire range from full to empty.
- Test two SOFC generator units at several NASCAR racing events as replacements for gasoline powered generators.
- Test SOFC generators in first responder applications with Folsom Police and Fire Departments.
- Analyze technical performance and human factors issues to evaluate readiness of the technology to move into commercialization phase.

Accomplishments

- Detailed analysis of NASCAR camera equipment power needs completed including baseline load evaluation and logistics evaluation.
- Focus group with City of Folsom, City of Sacramento, Office of Emergency Services, CalFire and Federal Emergency Management Agency has been conducted.
- Requirements definition completed.
- Desulfurization development and testing completed.
- Reformer development near completion.
- Mechanical packaging design and system testing underway.
- LPG fuel interface ready for system integration testing.

Introduction

Deploying a commercial power system into a portable space is a challenge for fuel cell applications. Moving a fuel cell power system from the laboratory to consumers' hands requires a complete systems or solution approach. A portable application requires consideration for real world conditions; requiring a wide array of control and power electronics to handle load following, startup/shutdown, safety considerations and system security. A level of ruggedness to handle frequent shocks from deployment and shipping is necessary as well as a convenient and safe fuel system interface. Jadoo has identified several specific applications related to outdoor sporting events and emergency response that are ideally suited to the technical characteristics of fuel cells and which would gain significant benefit from a fuel cell generator that could replace existing gasoline or diesel powered generators. This project entails the development of a portable fuel cell generator utilizing LPG fuel that can address the targeted applications.

Approach

Portable generators are to be developed by leveraging parallel work by Delphi Automotive related to use of a SOFC in a trucking auxiliary power unit (APU) application. Delphi SOFC technology will be modified and packaged for portable application with alternating current power capability. Delphi is modifying a reformer from its diesel APU to allow the use of LPG. Delphi is also developing a desulfurizer to allow use of commonly available consumer grade LPG as fuel source. Jadoo Power is developing an electromechanical fuel interface by leveraging prior learning from the development of an interface between proton exchange membrane fuel cells and metal hydride canisters for use by non-technical personnel.

Results

The requirements of the NASCAR application have been characterized. The general areas addressed include electrical power requirements, runtime requirements, and portability and mechanical requirements. One key application that has been targeted for application of the fuel cell generators is providing power to television cameras. These consist of fixed camera locations (with and without special effects modules) that are operated by camera people and remote camera locations with robotic mechanisms that are operated by a remotely located camera person. The power levels of the typical locations are shown in Table 1.

The desulfurizer subsystem has been selected, qualified and tested. A continuous performance test of the LPG desulfurizer for 40 hours has been conducted using a high sulfur content LPG source. The analysis data showed all sulfur species in the desulfurized LPG was generally below detection limits. Hence with an estimated dilution factor of 5~8, total sulfur level in the corresponding reformate would be expected to be <10 ppb.

TABLE 1. Television Camera Power Requirements Summary

CAMERA TYPE	NOMINAL POWER	PEAK POWER
Fixed camera without special effects module	150 Watts	170 Watts
Fixed camera with special effects module	200 Watts	220 Watts
Robotically assisted Remote camera	100 Watts	175 Watts

The reformer subsystem development and testing have been completed. Bench testing and characterization has demonstrated performance levels are at or near design targets.

Preliminary designs have been completed for the overall system packaging utilizing a "pit-box" form factor as shown in Figure 1. This form factor was selected as it is consistent with other equipment utilized by NASCAR and is compatible with the transportation requirements.

The LPG fuel interface prototype has been designed, fabricated and assembled (see Figure 2) and is ready for system integration testing.

Conclusions and Future Directions

The key technical risk elements of this development have been successfully addressed in bench testing and subsystem level implementations. The form factor will be larger than anticipated but will still be suitable for many application identified for the field trials.

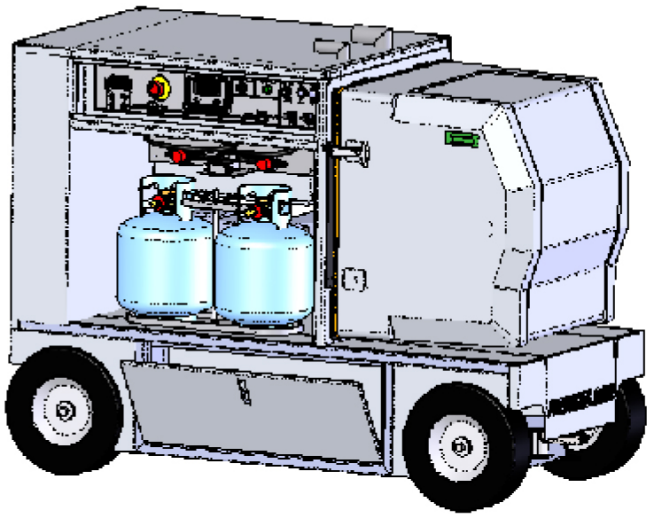

FIGURE 1. Mechanical Chassis Model

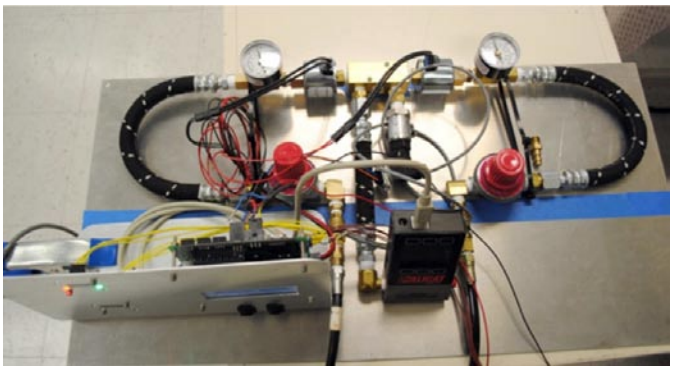

FIGURE 2. LPG Fuel Interface

The key remaining steps related to the program are as follows:

- Test the LPG interface to demonstrate measurement accuracy of +/- 10%.
- Fabricate the mechanical chassis.
- Integrate the subsystems together on the mechanical chassis.
- Perform system level testing and validation.
- Deploy the systems in the field trial with NASCAR.
- Deploy the systems in the field trial with the City of Folsom, CA.
- Gather the field trial data and prepare the final reports.