X.1 Development of Advanced Manufacturing Technologies for Renewable Energy Applications*

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Objectives

This project will address selected key manufacturability issues needing solution in two hydrogen technology areas: storage and the production of components.

- NCMS will evaluate, identify, and develop manufacturing technologies vital to affordable hydrogen-powered systems.
- NCMS will leverage manufacturing technologies from other industrial sectors and work with its extensive industrial membership to do feasibility projects on those technologies identified as key to reducing production cost by rendering a system component or subcomponent of the targeted hydrogen-powered systems producible in volume.

Technical Barriers

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

Fuel Cells

(A) Lack of High-Volume Membrane Electrode Assembly (MEA) Processes

(B) Lack of High-Speed Bipolar Plate Manufacturing Processes

(C) Lack of High-Speed Sealing Techniques

(E) Lack of Manufacturing Processes for Balance of Plant Components for PEM Fuel Cell Systems

(F) Low Levels of Quality Control and Inflexible Processes

Storage

(H) Lack of Carbon Fiber Fabrication Techniques for Conformable Tanks

Technical Targets

(from the Manufacturing R&D section of the Hydrogen, Fuel Cells and Infrastructure Technologies Program Multi-Year Research, Development and Demonstration Plan)

Fuel Cells: Presently, automotive fuel cell stacks are fabricated at low volume, and the cost of these stacks is approximately $3,000 per kW. This is 50 times the projected cost of $60 per kW for the same stack technology (2006) at high volume (500,000 units). The projected high-volume cost includes labor, materials, and capital expenditures, but does not account for manufacturing R&D investment. The objective of manufacturing R&D is to enable this factor of 50 cost reduction in automotive fuel cell stacks.

Hydrogen Storage: The current 10,000 psi gaseous storage system is estimated to cost $420 to $240/kWh. The Program's target for all on-board storage technologies is $2/kWh by 2015. (See Figure 3.3.4 in the HFCIT Program Multi-Year Research Development and Demonstration Plan: Status of current technologies relative to key system performance and cost targets.) The objective of manufacturing R&D is to reduce the cost of making high-pressure carbon composite storage tanks by a factor of nine from 2005 costs.

Progress Towards Technical Targets: This project is conducting several aspects of manufacturing R&D applied to fuel cell components, and to the storage of hydrogen. The primary focus is to bring higher volume manufacturing techniques to target systems to increase volume and significantly lower costs, consistent with the technical targets outlined above.

Accomplishments

- In fuel system storage:
  - Subassembly fabrication scrap rate reduced from 75% to less than 5%.

- Bladder assembly process steps reduced by 25%.
- Fabrication process time reduced by a factor of 10.
- Projected manufacturing processing costs reduced by a factor of eight to 10.
- Material types used in bladder assemblies reduced from six to two.
- All materials except the hydrogen membrane are recyclable.
- Testing demonstrated reliability of the bladder manufacturing process.

- Freudenberg-NOK General Partnership (FNGP) and UTC Power have developed a customized elastomer seal material with a low level of contaminants and reduced compression set as compared to silicone. An advanced seal design and durable carrier film have been proven to meet tight tolerances and durability.
- Processing experiments and sample evaluations have demonstrated capability for achieving a sub-20-minute process and a path to a six-minute cycle. Fabrication of initial test cylinders has begun.
- Cabot has had limited success using inkjetting of MEAs on an alternate platform. Resolution efforts continue.
- Performance of the new generation MEA is comparable to older MEA generations. The stack has been running for almost 620 hours. The total output of the stack is 65 W. The performance decay rate of the stack is expected to meet the operating life target.
- Non-destructive testing and evaluation (NDTE) methods including acoustic emissions (AE), Modal AE, ultrasonic testing (UT) and other advanced NDTE technologies are being evaluated for compressed hydrogen tanks. A database was begun on FRAE (frictional AE). Higher pressurizations lead to more FRAE. FRAE is interesting because it is repeatable and can be used for source location. A large amount of FRAE may indicate a large amount of damage.
- The manufacturing cost of targeted balance-of-plant components will potentially be reduced by 50% in the near-term (end of this project) and by 90% with volumes of approximately 100 pieces per year. Low-cost manufacturing technologies and associated materials are being qualified for PEM fuel cell power system applications.
- Demonstrated a single-step methodology for manufacturing PEM fuel cell stacks based on a mass-producible injection molding process. Bipolar plates with molded features offer significant cost savings over machined plates used for prototypes. The tooling to produce the molded plates came in and the performance of the molded plates is equal or better than that of the machined plates.

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Introduction

Manufacturing issues are vital to the successful commercialization of fuel cell systems. Highly performing systems cannot be used unless they can be efficiently and repeatably manufactured. This project addresses several manufacturing issues that need to be solved for successful commercialization. Without a strong effort towards the manufacturing of fuel cell and storage systems, the U.S. is in danger of losing its leadership role in the production and use of fuel cell systems.

Approach

Great strides are being made in improving the performance of hydrogen-powered systems. To date, the R&D focus has been on performance and efficiency of the systems. However, to make affordable hydrogen-powered systems, addressing manufacturability issues will be vital to ultimate commercialization. Our approach includes:

- Working with key stakeholders, development of a prioritized, consensus list of current barriers, concerns, and issues related to manufacturability:
  - Extracting information from currently available industry and government roadmaps, specifically regarding identification of process technology needs.
  - Consulting with and consensus building among stakeholders to prioritize manufacturability needs and formulate potential project designs to address these needs.
- Structuring and conducting collaborative projects addressing selected prioritized manufacturing technologies to demonstrate and/or substantially improve the economic production of hydrogen storage systems and the production of components.

Results

Eight manufacturing projects are being performed under this project. This results section summarizes these efforts.

1. Non-Destructive Testing and Evaluation Methods

Team Members: American Society of Mechanical Engineers (ASME) Standards Technology, Digital Wave, Lincoln Composites and TransCanada Pipelines

Problem/Impact: Hydrogen storage and transportable vessels have operating requirements of 10,000 psi compressed hydrogen for fuel tanks in commercial automotive fuel cell vehicles (FCVs) and 15,000 psi for transportable pressure vessels to support the refueling infrastructure. To meet cost and weight targets the manufacture and testing of composite pressure vessels is critical.

Current composite pressure vessel manufacturers conduct destructive pressure-burst tests to verify product integrity and to meet existing code rules. Overall manufacturing cost is increased by these tests that are costly in labor and cycle time, lost product and are performed under strict safety guidelines only by trained personnel using specially built chambers, etc. A single pressure-burst test is frequently not sufficient for a single design or lot. Multiple tests can be cost prohibitive for low-quantity or custom pressure vessel orders.

Results:

Vessels Tested – Three composite pressure vessels were tested at Lincoln Composites on April 23, 24 and 25, 2007. The vessels were intended for hydrogen service. Working pressure is 12,500 psi. The test goal was to see if Modal AE could detect the presence of damage and if that damage led to lower than normal burst pressure. We are searching for very practical techniques for monitoring these vessels in service that would provide the assurance needed by both the customer and the automotive industry.

613-003 had been tested to 15,000 psi; retested to 18 ksi. This vessel was subsequently subjected to a 6-foot drop test. Then it was burst tested.

613-018 had been tested to 15,000 psi; retested to 18 ksi. This vessel was subsequently subjected to multiple cuts to various depths through its outer fibers. Then it was burst tested.

613-001 was an unproved (virgin) vessel. It was tested to 18 ksi. This vessel was subsequently subjected to drilled holes. The holes were different diameters but were drilled all the way through to the plastic liner. Metal screws were glued into the holes to help prevent the liner from bulging, if necessary. Then it was burst tested.

AE sensors were coupled to each vessel and the fracture sounds were monitored. Preliminary results are that the AE technique was able to indicate the position and presence of the damage after it had been inflicted. Before damage had been inflicted, AE indicated that the vessels were normal, meaning no detectable defects, and it could be expected that, had they been tested to burst at that point, burst pressures would have fallen into the usual range typical of acceptable vessels. Detailed data analysis should confirm these preliminary observations and provide further information about the capability of the Modal AE NDTE technique.

Monitoring System: Procurement efforts are ongoing, proper adhesives have been identified, and the design stage has commenced.

2. Affordable High-Rate Manufacturing of Vehicle-Scale Carbon Composite High-Pressure Hydrogen Storage Cylinders

Team Members: Profile Composites, Cincinnati Technologies/Cincinnati Automation & Test, Bayer MaterialScience and selected original equipment manufacturer (OEM).

Problem/Impact: Production of high-pressure storage cylinders for on-board hydrogen is currently incompatible with vehicle introduction from both a cost and production-rate standpoint. The objective of this project is to implement and demonstrate a high-pressure hydrogen storage cylinder manufacturing process in an automotive production environment, compatible with low-volume and specialty vehicle production rates of approximately 20,000 vehicles per year on a single tooling line.

Results:

Requirements definition, test article design and, tooling design are complete. Tooling fabrication, materials evaluation and process development are proceeding. Insights gained from project participants have already benefited the anticipated project outcomes. Significant effort is being focused to best address factors for implementing the final product in an automotive production environment, including production automation, and for addressing some of the issues seen in previous tank work across the industry. A new source of high-strength carbon fiber, not subject to priority demands from the aerospace industry, was identified, and samples obtained for this project. Some delay has been incurred in transferring resin sample lots to Profile Composites and in procurement of initial subscale aluminum liners for initial test cylinders. No significant schedule impact is foreseen.

3. Manufacturable Chemical Hydride Fuel System Storage for Fuel Cell Systems

Team Members: Millennium Cell, Dow Chemical, Edison Welding Institute and NextEnergy

Objective: To develop a manufacturing process to produce cost effective flexible bladder and cartridge systems to manage the fuel and discharged fuel of a chemical hydride-based hydrogen storage system.

Results:

The original bladder design incorporated six different materials, none of which were recyclable. Through materials research and testing, the bladder is now manufactured using only two materials. The material used for all components of the bladder except the hydrogen membrane is recyclable; this material makes up over 60% of the total bladder materials. The hydrogen membrane, making up less than 40% of the bladder assembly, is not currently recyclable. Work continues to find a recyclable membrane material.

The initial fuel bladder subassembly fabrication process resulted in a scrap rate of approximately 75%. This was due to a number of factors primarily related to heat sealing of the bladder film, membrane material, and fitments. Bladder and fitment design changes as well as improved heat sealing techniques and equipment reduced the scrap to less than 5%. Further improvements in equipment that would result from an automated process are expected to reduce the scrap rate even further.

During the course of the project the assembly process flow was analyzed to reduce assembly time. As a result the assembly process steps were refined and reduced by 25% and the subsequent fabrication time was lowered by a factor of 10. These actions, combined with reductions in the number and type of materials used in the bladder assembly are projected to result in a manufacturing cost that is eight to 10 times lower than the initial process. Further reductions are possible by fully automating the fabrication process.

After the process and material improvements were implemented, bladder assemblies were fabricated and tested. The objective of the testing was to determine the reliability and robustness of the manufacturing process. Testing of the first set of bladder assemblies revealed a weakness in the process. Modification to the process and the design were implemented and additional bladder assemblies were tested. All of these bladders passed.

4. Novel Manufacturing Process for PEM Fuel Cell Stacks

Team Members: Protonex Technology and Parker Hannifin

Objective: To develop and demonstrate a single-step methodology for manufacturing PEM fuel cell stacks based on a mass-producible injection molding process. In addition to being highly cost-effective, the process will also result in excellent stack performance. The performance targets for the fuel cell stacks are summarized in Table 1.

TABLE 1. Project Targets

	Project Targets	Units
Power	250	W
Active Area	16.7	cm^2
Footprint	33	cm^2
Volume	790	cm^3
Mass	680	g
Active Area to Footprint	51%	
Volumetric Power	316	W/L
Specific Power	368	W/Kg

Results:

Design and Process Validation

Process Validation – Detailed process documentation and procedures were generated for the stack manufacturing and break-in process. These procedures were developed and refined with stack builds at Protonex and input from Parker. Once the documentation and process definition was completed at Protonex the process was validated at Parker.

Stack components, manufacturing fixtures and procedures were sent to Parker's facility in Woburn. The results of these builds have been excellent. Parker was able to transfer and reproduce the process based on the documentation package and produce high-performing stacks right from the start. This validation task has demonstrated that the single-step injection molded stack build process is indeed robust and transferable.

Molded Plates – Bipolar plates with molded features offer significant cost savings over machined plates used for prototypes. The tooling to produce the molded plates came in and the performance of the molded plates has exceeded that of the machined plates. This is believed to be attributable to two factors; the molded plates have smoother features (no sharp corners) which may facilitate water clearing and the plate-to-plate variation of the flow fields is less.

Design and Process Performance – Process definition, refinement and performance improvement has continued. During the 6th quarter, 44 more stacks were produced. Over the course of the project, the steady improvement of the process is evidenced by steady performance increase from the first stacks at just over 300 W to the most recent stacks around 380 W at nominal conditions.

In summary, the process validation phase has shown that the stack design and single-step injection molded process is robust, stable, low-cost and transferable.

Stack Life and Performance

Stack Life Testing – Stack life testing has continued on the stack life test stand. The stack design has demonstrated over 2,000 hours of runtime thus far, with a voltage decay rate of 5.6 µV/cell/hour. This translates to a loss of less than 5% of initial performance over the desired life of 3,000 to 5,000 hours for most portable applications. This result far exceeds the target of 10% performance degradation.

Breadboard System Testing – Stack life testing has continued in system breadboard configuration. Stack 241978 has been tested for over 1,500 hours on an actual breadboard system. This test shows the performance and durability of this stack design in a real system operating environment. The stack continues to put out approximately 300 W after over 1,500 hours of runtime on the breadboard system.

Start-Stop Cycling – Another area of testing has been start-stop testing. In actual portable fuel cell applications stacks may see up to 1,000 start-stop cycles. Figure 1 shows the results of a test with greater than 700 start-stop cycle. The cycling was paused at just over 500 cycles to monitor the steady state performance (~250 hours) of the stack after cycling. The stack performance under this start-stop test has exceeded targets and the test is expected to far exceed the 1,000 cycle target.

Project Technical Results:

The stack design and manufacturing process have exceeded the project technical targets. The stack exceeds the volumetric and specific power targets of the project, is cost-effective and exhibits excellent performance stability and life. The final stack configuration is in Figure 1.

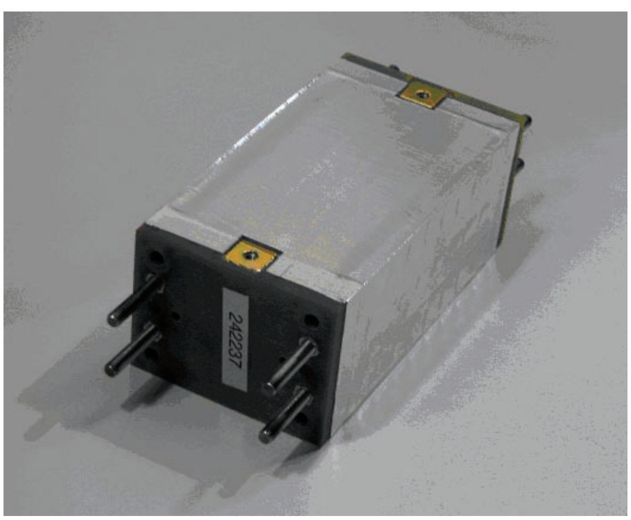

FIGURE 1. Final Stack Configuration (5.3 cm x 7.0 cm x 15.3 cm)

Performance against project technical targets are provided in Table 2.

TABLE 2. Project Technical Results

	Project Targets	Results Achieved	Units
Power	250	350	W
Active Area	16.7	18.0	cm^2
Footprint	33	36.9	cm^2
Volume	790	568	cm^3
Mass	680	884	g
Active Area to Footprint	51%	48.8%	
Volumetric Power	316	616.2	W/L
Specific Power	368	396	W/kg

Plans for Next Quarter and Key Issues:

The plan is to start work on Phase II of the project which will be low-cost 250 W integrated balance of plant. This task will build on the results of the stack phase and focus on optimizing the balance of plant for manufacturing.

5. Innovative Inkjet Printing for Low-Cost, High-Volume Fuel Cell Catalyst Coated Membrane (CCM) Manufacturing

Team Members: Cabot Superior Micropowders and MTI Micro Fuel Cells

Objective: The goal of this project is to provide an innovative solution based on inkjetting technology for low-cost, high-performance, high-volume fuel cell catalyst-coated membrane (CCM) manufacturing to accelerate fuel cell commercialization.

Background: The cost of manufacturing catalyst-coated membrane/membrane electrode assembly (CCM/MEA) is too high and the coated electrocatalysts such as platinum (Pt), platinum ruthenium (PtRu) are too expensive, which become key technical barriers for fuel cell commercialization. It is critical to develop a revolutionary manufacturing technology which allows high-volume production of CCM/MEA with lower Pt content (low-cost) and high fuel cell performance under this project.

This technology can be easily applied to other areas by printing catalysts on substrates for other industries, e.g. membrane reactors, gas separation membranes coated with selective catalysts, other type fuel cells (like solid oxide fuel cells), electrolyzers, ultracapacitors, batteries, etc.

Results:

- Cabot's low Pt loading CCM/MEAs have been demonstrated with excellent performance in direct methanol fuel cells (DMFCs) using newly developed supported catalysts.
- Cabot developed a technology to advance platinum/carbon (Pt/C) catalyst ink with reduced particle size. Related solvent and dispersant systems have been developed and optimized. The ink was demonstrated with good stability and compatibility with the inkjet process.
- Cabot improved an ink formulation to minimize the side effect of solvent and dispersant of the ink so that the DMFC MEA performance is maximized.
- Cabot successfully demonstrated inkjetting to make double-sided CCMs using a substitute hardware platform (Figures 2 and 3).

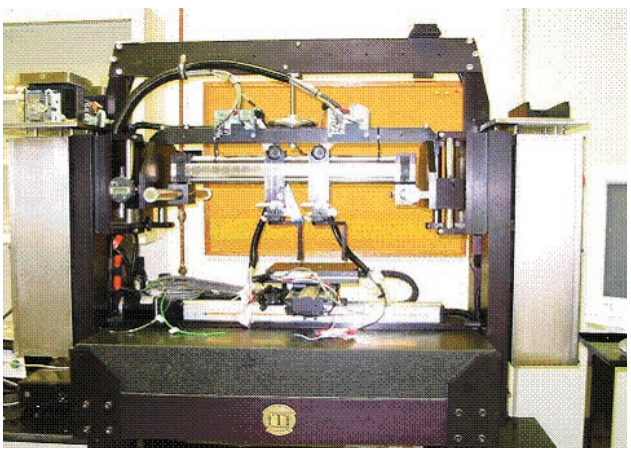

FIGURE 2. Cabot's Original Inkjet Development Platform for CCMs

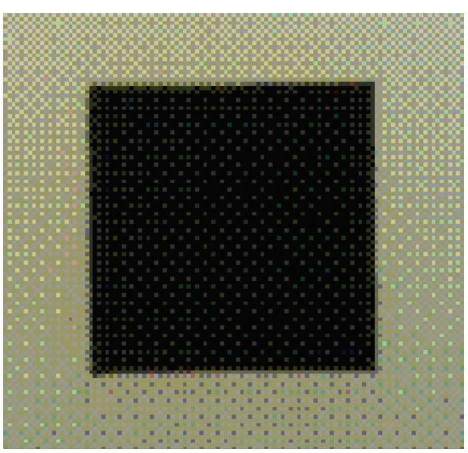

FIGURE 3. Cabot's Inkjet CCM

- Inkjet CCMs have been evaluated by MTI and performance is being compared with spray process CCMs and baseline hand painted samples.
- Cabot developed accelerated durability testing protocol and demonstrated excellent durability with end of life >80% beginning of stack life.

6. Manufacture of Durable Seals for PEM Fuel Cells

Team Members: UTC Power and Freudenberg NOK

Objective: The objective of this project is to produce a durable seal to be manufactured in high-volumes for use in PEM fuel cell applications. The advanced seal design will have a thin cross section, large plan view footprint elastomer molded onto a thin carrier film with short cycle times.

There are four milestones that align to the tasks in the plan for this project.

- Milestone 1 – Material Property Selection and Seal Design
- Milestone 2 – Tool Design and Fabrication
- Milestone 3 – Molding Process Optimization
- Milestone 4 – Cell Stack Verification

Background: Considerable efforts are being spent towards building a hydrogen infrastructure for automotive and stationary power. Mature PEM fuel cell technology is a requisite for harnessing this infrastructure. To provide sufficient power and voltage, individual PEM fuel cells are stacked in series to yield a cell stack assembly (CSA). At the basic level, each cell contains an anode, cathode, membrane separator and an interfacial seal. The lifetime of the CSA is limited by the repeat elements. With careful control of the operating conditions, lifetimes equal to that of the interfacial seals and membranes can be achieved. Efforts are currently underway to improve membrane lifetimes. However, very little is being done in the area of seal durability.

Seals that are used in the automotive and the general industry have well defined designs and manufacturing methods. The designs have evolved from the flange design, component tolerances or flange tolerances and the sealing material. In comparison, the sealing requirements for PEM fuel cells present an enormous challenge. Besides the electrochemical environment and the need for a chemically stable (non-poisoning) material, the seal must be very thin, cover a large footprint and be able to accommodate large flange tolerances at very low contact pressures. In addition, the seal must be produced in very high-volume with very tight tolerances.

For PEM fuel cells, the lifetime of the interfacial seal is limited by the material choice and design. The most common interfacial seal material is silicone. Silicones are chosen for their excellent corrosion resistance in acidic environments. However, silicone materials are generally unstable over long times and have the potential to migrate from the seal area into the active area of the fuel cell. This has a deleterious effect on fuel cell performance and also results in reduced lifetimes.

As a part of a separate project, UTC Power and FNGP have developed a custom elastomer material that exhibits vastly superior chemical and mechanical properties compared to conventional silicones. In addition to eliminating concerns of silicone catalyst contamination, the newly developed elastomer has improved compression set resistance and a low level of ionic contaminants. The two companies also researched low-cost carrier materials for the elastomer. A low-cost long life alternate carrier material has also been identified.

Based on the non-silicone material developed and the alternate low-cost and high-durability carrier material, UTC Power and FNGP have arrived at an advanced interfacial seal design. The design is achievable by molding the advanced elastomer onto the carrier material. It is desirable to use the new seal design to replace the previous seals at all cell interfaces in the PEM stack. Since each cell in a fuel cell stack requires one or more seals and each stack contains hundreds of cells, it is necessary to develop a high-volume manufacturing process to make this feasible. This requires significant development of a molding process and new tooling to attain the required high-precision molded seals.

Results:

Milestone 1 – Material Property Selection and Seal Design

Material Property Testing and Selection:

- *Shrinkage* – Results have been obtained and are being used in tool design.
- *Elongation* – Measurements have been made at FNGP and have been confirmed by UTC. Aged and un-aged samples have been tested at UTC to ensure the long-term viability of the materials in a fuel cell environment.
- *Tear Strength* – Measurements have been completed.
- *Flow Characteristics* – Completed characterizations and data is being used in tool design.
- *State of Cure* – State of cure studies were conducted at FNGP to verify the behavior of the materials during processing. Final testing specific to this seal and the process characteristics that will be used will be conducted during process optimization.
- *Adhesion* – Extent of adhesion to carrier films has been determined for both materials.
- *Finite Element Analysis (FEA)* – FEA has been done using the material properties and several seal design iterations to come up with the best design for our application and cell stack design.
- *Seal Design* – Seal design is complete and has been forwarded to FNGP. FNGP had some questions regarding the print which is being updated to reflect the new clarity on dimensions.

Milestone 2 – Tool Design and Fabrication (complete)

- *Pressure sensitive adhesive process optimization* – A component specification and manufacturing process flow has been established.
- *Tool design* – Tool design completed on January 19, 2007. Tool fabrication completed March 19, 2007.

Milestone 3 – Molding Process Optimization

- Mold process has been optimization.
- Adhesive application optimization in progress.
- Piece cutting optimization in progress.

Milestone 4 – Cell Stack Verification

- To begin upon process verification – verification stack build begins May 5, 2007.
- Hardware and other verification stack components expected in-house by April 25, 2007.

Plans for Next Quarter and Key Issues:

- Finalize optimization process.
- Discuss inspection outcome.
- Receive parts at UTC Power for verification stack build.

7. Qualifying Low-Cost High-Volume Manufacturing Technologies for PEM Fuel Cell Power Systems

Team Members: UTC Power, General Pattern and Lawrence Berkeley National Laboratories (LBNL)

Problem/Impact: Cost and durability are two of the major barriers to commercialization of proton exchange membrane fuel cell (PEMFC) power systems for transportation applications. Several low-cost high-volume manufacturing technologies can be used to potentially lower the cost of PEMFC power systems. However such manufacturing technologies generally rely on the use of particular classes of materials. Material compatibility with PEMFC systems is a major concern with these technologies because PEM fuel cells have unique material requirements.

Benefit: The cost of targeted components will potentially be reduced by 50% in the near-term (end of this project) and by 90% with volumes of approximately 100 pieces per year. Low-cost manufacturing technologies and associated materials will be qualified for PEMFC power system applications. This project will expand the portfolio of qualified manufacturing technologies and materials for PEMFC power systems and therefore lower the barrier for component suppliers to enter the PEMFC component market.

Results:

- Qualified Polyone® black polypropylene material at LBNL for use in a PEM fuel cell power plant. General Pattern manufactured tooling and injection molded an assembly (cathode exit elbow) using Polyone® polypropylene resulting in a 95% reduction in part cost. An added benefit was that part weight was reduced by 80%. UTC Power installed the injection molded cathode exit elbow on two PEM cell stack assemblies in a production fuel cell power plant designed for transit bus applications. This production fuel cell power plant successfully completed production acceptance testing at UTC Power and has been installed in a fuel cell hybrid bus that will be used in revenue service as part of an endurance demonstration.
- Qualified high density polyethylene (HDPE) material at LBNL for use in PEM fuel cell power plants. General Pattern manufactured tooling and is preparing to mold an assembly (air inlet manifold) for use in a PEM fuel cell power plant. UTC Power will install the air inlet manifold in a PEM fuel cell power plant in July. This power plant will be operated in transit bus service as part of an endurance demonstration. The molded manifold will result in a 90% reduction in part cost with an estimated weight savings up to 75%. This molded manifold contains integral metal inserts for mounting as well as features for instrumentation connections (threaded ports and O-ring interface surfaces.
- Qualified virgin polypropylene for use in water treatment bottle. UTC Power installed polypropylene water treatment bottles in PEM fuel cell power plants resulting in >90% reduction in part cost over the previous water treatment bottle. Fuel cell power plants with this improvement have been installed in fuel cell hybrid buses operating in revenue service as part of an endurance demonstration.
- Qualified Banjo® black polypropylene material at LBNL. UTC Power installed a component (filter) made of Banjo® polypropylene in PEM fuel cell power plant thermal management systems installed in buses in the field. The new part simplifies maintenance due to an easily removable filter element. Prior filter element was a welded screen that was inaccessible for cleaning.
- UTC Power has deemed certain materials (silicone rubber and EPDM-lined hose) unacceptable based on material compatibility testing at UTC Power and LBNL.
- General Pattern is fabricating tooling for a molded assembly using HDPE (cathode inlet elbow). Parts are expected in July resulting in a 95% reduction in part cost and up to 75% reduction in weight
- LBNL has developed a materials compatibility test for qualifying materials for PEM fuel cell applications. The testing process focuses on the extraction of component materials with distilled water and organic solvents in order to identify potential contaminants.

8. Develop Low-Cost MEA3 Process

Team Members: DuPont and Smart Fuel Cell (SFC)

Objective: The main objective of this collaborative project is to develop and validate a high throughput, high productivity coating process used for manufacturing of MEAs. Significant aspects include:

- **Feasibility assessment of high throughput screen printing process** – assess feasibility of high throughput screen printing processes.
- **Transfer functions** – develop relationships between MEA manufacturing control points and performance of MEA stacks.

Results:

Following are DuPont's main achievements:

- Completed feasibility of two coating processes: automated printing and roll-to-roll coating process.
- Selected low-cost/high throughput coating process to drive cost down and meet current market needs.
- Demonstrated MEA performance at customer facility using new electrode chemistry and process technology.

Table 3 is a summary of the preliminary performance data from fuel cell platform tests conducted internally and at SFC in their production fuel cell systems.

Single Cell Performance:

Single cell performance was measured using Protocol 9A and operating conditions given in Table 3.

TABLE 3. Operating Conditions

Variable	Single Cell	Stack/system
Cell type	25 cm^2	50 cm^2,
Airflow rate/Stoich	3	2.5
Methanol flow rate/Stoich	4	4
Methanol conc.	1 M	0.7 M
Cell temperature	70°C	75°C

Stack Performance:

The stack has been running for almost 620 hours. The total output of the stack is 65 W. The performance decay rate of the stack is expected to meet operating life target. The stack is still running.

FY 2007 Publications/Presentations

1. Poster Session – DOE Review Meeting