FUEL CELL MANUFACTURING R & D

Presently, Polymer Electrolyte Membrane (PEM) fuel cell stacks are fabricated at low volume, and the costs of these stacks range from $3,000 to $5,500 per kilowatt (kW) [1]. This is 50 to 90 times the projected cost of $60 per kW[2] for the same stack technology (2006) at high volume (500,000 units). In addition, six sigma standards must be reached for fuel cell subsystems and components to be competitive with conventional power systems such as internal combustion engines. Topics I through 5 described below provide a summary of the high-priority manufacturing needs for PEM fuel cell Membrane Electrode Assemblies (MEAs) and stacks. The overall goal is to reduce the cost of manufacturing by several orders of magnitude toward the Program's target of $30 per kW while demonstrating the ability to achieve six sigma quality standards.

Topic 1 Alternative Electrode Deposition Processes

The current processes for deposition of electrode materials for both Catalyst Coated Membranes (CCMs) and Gas Diffusion Electrodes (GDEs) can not be scaled up to meet the needs of high volume production requirements. Alternative processes using, for example, ink jet, liquid inks, and novel electrode particle dispersion techniques are needed for higher layer uniformity, higher product volume throughput, and lower overall product cost.

The research project should include:

1) Analysis of current processes for electrode deposition and an evaluation of various practical alternative processes in terms of expected process time, particle deposition uniformity, and defect rate;
2) Recommended alternative process;
3) Design study to determine the feasibility and manufacturability of the proposed technique(s) including any associated environmental issues;
4) Cost analysis showing the manufacturing cost of the new technique(s) in terms of expected cost categories:

Variable Cost Elements:
    Material, Direct Labor, Utility
Operating Fixed Costs:
    Tooling & Fixtures, Maintenance, Overhead Labor, Cost of Operating Capital
Non-Operating Fixed Costs:
    Equipment, Building, Cost of Non-Operating Capital

The expectation is that applications in this area will deliver research results that verify the techniques developed and will provide a viable process to meet high volume cost targets for MEA manufacturing while achieving a six sigma standard.

Applicant cost share requirement: 30% minimum

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[1] Fuel Cell Meeting (4/26/07) National Weather Service

[2] TIAX 2006 estimate for 80 kW automotive fuel cell systems

The total DOE funding for Topic 1 will be up to $6 million (not including 30% cost share) with up to three awards. The projects will be three to four years in length.

Topic 2 Novel MEA Manufacturing

Novel approaches to manufacturing MEA's has the potential to reduce the component count of a stack and allow alternative, lower cost approaches to cell construction. In addition, MEA durability could be increased by an improved manufacturing design.

The research project should include the development of:

1) Analysis of current processes for MEA manufacturing and a comparison of the attributes and costs of the applicant's MEA design concept;
2) Design study to determine the feasibility and manufacturability of the proposed technique;
3) Bench scale experimental test data that demonstrates the new MEA performance results;
4) A cost study showing the manufacturing cost of the new technique(s) for expected cost categories:
   Variable Cost Elements: Material, Direct Labor, Utility
   Operating Fixed Costs: Tooling & Fixtures, Maintenance, Overhead Labor, Cost of Operating Capital
   Non-Operating Fixed Costs: Equipment, Building, Cost of Non-Operating Capital.

Applicant cost share requirement: 20% minimum

The total funding for Topic 2 will be up to $8 million (not including 20% cost share) with up to two awards expected. The projects will be three to four years in length.

Topic 3 Rapid MEA Conditioning

After cell stack assembly, a break-in period (including leak testing) is necessary to test and condition the MEAs and other assembled components for operations and to ensure the stack is performing according to specifications before assembling the entire fuel cell system. This break-in period is performed on a test stand and currently takes many hours per stack; it is a significant time and cost driver for an assembled fuel cell system. New off-line MEA pre-conditioning and testing methods or techniques are needed to significantly reduce or eliminate the break-in period.

The research project should include the development of:

1) A design concept that either eliminates the need for conditioning steps or provides for conditioning the MEA before stack assembly to assure the MEA will perform to specifications thereby significantly reducing the process duration;
2) Experimental test data that demonstrates that the new method or technique achieved the results developed in Item 1.

Applicant cost share requirement: 30% minimum

The total DOE funding for Topic 3 will be up to $7 million (not including 30% cost share) with up to two awards. The projects will be three to four years in length.

Topic 4 Process Modeling for Fuel Cell Stacks

The current Design-For-Manufacture (DFM) or Design-For-Assembly (DFA) techniques applied to manufacturing conventional technologies such as internal combustion engines do not necessarily carry over and apply to fuel cell stacks. New computer-based models are needed to enable designs that intensify processes, reduce part counts, and simplify manufacturing of bipolar plates, MEAs and stacks. The new models will foster development of high volume, efficient stack assembly processes and drive component standardization at the stack level. These new models will also help to facilitate achieving six sigma quality standards. The models should enable designs that integrate MEA components including edge and interfacial seals and gaskets. The models should also enable combining component functions and work steps such as, merging the MEA and bipolar plate sealing and assembly processes into a continuous process.

The research project should include:

1) Benchmarking of current processes, including development of process flow diagrams identifying working steps, techniques, throughput times, attrition rates, and quality levels for bipolar plates, MEA and stack manufacturing;
2) Assessing the most cost-effective way to manufacture / assemble the finished stack, including all of the components;
3) Developing a computer-based fuel cell system and/or components manufacturing models with features for analyzing work steps in terms of alternatives, combining steps, simplifying processes, and standardizing component or subsystem dimensions.

The expectation is that applications on this Topic will demonstrate the cost and quality differences when variations to a benchmark set of product and process designs are provided as input.

Applicant cost share requirement: 20% minimum

The total DOE funding for Topic 4 will be up to $5 million (not including 20% cost share) with up to three awards. The projects will be two to three years in length.

Topic 5 Process and Device for Cost Effective Testing of Cell Stacks

Currently, cells are assembled and tested manually and only one at a time in testing equipment that is very expensive. High-rate (i.e., 10,000 to 100,000 stacks per year) and low-cost methods need to be developed for testing the sealing of cells, end plates and reactant and cooler manifolds to design specifications. New low cost test cells are needed to facilitate rapid testing and assembly of the cell stack and the elimination of the need to test each cell component during cell stack assembly.

The research project should include the development of:

1) Low cost, non-destructive quality control measuring devices;
2) Rapid leak testing equipment to assure the cell stack fulfills the leak specifications in the least possible time.

Applicant cost share requirement: 30% minimum

The total DOE funding for Topic 5 will be up to $12 million (not including 30% cost share) with up to three awards. The projects will be three to four years in length.

ON-BOARD HYDROGEN STORAGE SYSTEM MANUFACTURING

The current high pressure, i.e. 10,000 psi gaseous, hydrogen storage system cost range is from $240 to $420/kilowatt-hour (kWhr)[3]. The Program's target for all on-board hydrogen storage technologies is $2/kWh by 2015. The objective of manufacturing R & D is to reduce the cost of making high-pressure carbon composite storage systems.

Topic 6 Manufacturing Technologies for Reducing the Cost of High Pressure Composite Conformable Tanks

Composite tanks require high-strength fiber (700 ksi) made from carbon-fiber grade polyacrylonitrile (PAN) precursor. This high grade carbon fiber is about $15 to $20/kg. Manufacturing R&D is needed to develop lower cost, high quality polyacrylonitrile (PAN) or alternate precursors and reduced energy or faster carbonization processes for carbon fiber, such as microwave or plasma processing. In addition to improved carbonization processes, other steps in the process, such as oxidation and graphitization, need to be accelerated. Fiber placement technologies can reduce unit costs by reducing the amount of carbon fiber needed by as much as 20%-30%.

New manufacturing methods for carbon fiber winding and fiber placement manufacturing are needed to improve conformability of tanks by allowing modified cylindrical tank shapes to be manufactured. A cost model is needed to guide development of high-volume production processes for high-pressure composite tanks employing fiber placement technologies.

It is also necessary to develop new manufacturing methods for high-pressure composite tanks that can reduce the cycle time, that is, the per unit fabrication time. Potential advances in manufacturing technologies such as faster filament winding, new filament winding strategies and equipment, and continuous versus batch processing should also be investigated.

The research project should include the development of:

1) New precursor materials and processes for lowering material costs and energy needs;
2) Analysis of current processes for carbon fiber placement and winding;
3) Cost model capable of evaluating new fiber placement and winding processes;
4) New manufacturing technologies that dramatically reduce the time and cost of fabricating high-pressure composite tanks;
5) Laboratory testing and demonstration of a product scale 5 kg high-pressure composite storage system.

Applicant cost share requirement: 30% minimum

The total DOE funding for Topic 6 will be up to $10 million (not including 30% cost share) with up to two awards. The projects will be three to five years in length.

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[3] Based on cost estimate from available products (www1.eere.energy.gov/hydrogenandfuelcells/mypp/pdfs/manufacturing.pdf)