Manufacturing R&D

The Manufacturing R&D program in the Fuel Cell Technologies Office (FCTO) aims to improve processes and reduce the cost of manufacturing components and systems for hydrogen production and delivery, hydrogen storage, and fuel cells for transportation, stationary, and portable applications. Industry will have to overcome significant challenges to scale up production of today's hydrogen and fuel cell related components and systems, currently built using laboratory-scale fabrication technologies, to high-volume commercially viable products. In addition, cross-cutting technologies and capabilities such as metrology and quality control standards, modeling and simulation tools for efficient manufacturing processes, and the development of a domestic supplier base are necessary to continue the establishment of a robust, domestic hydrogen and fuel cell manufacturing industry.

Figure 1. Industrial-style roll-to-roll web-line at the National Renewable Energy Laboratory. The web-line is used to develop and validate in-line inspection methods for fuel cell components, including membranes, electrodes and gas diffusion media.

Why is this Important?

Approximately 30,000 fuel cell systems were shipped worldwide in 2012, representing more than 120 MW of power. As the market for hydrogen and fuel cells grows, the need for development of automation and manufacturing processes for mass production of these systems becomes increasingly critical. To meet the needs of increasing production volumes, FCTO's Manufacturing R&D program works with industry, universities, and national laboratories to research, develop, and demonstrate high-volume manufacturing processes and technologies to reduce cost while also maintaining performance.

What are the Challenges?

Fuel Cells

The ramp-up to high-volume production of fuel cells will require quality control and measurement technologies consistent with high-volume manufacturing processes (see Figure 1). Manufacturers will need process control strategies specific to producing fuel cell components to reduce or eliminate sampling and testing of components, modules, and subsystems. As fuel cell manufacturing scales up, the relationships between fuel cell system performance, manufacturing process parameters, and variability must be clearly understood. Such understanding will likely play a major role in fuel cell system design, acceptable tolerances, and specifications and is integral to implementing design for manufacturability.

Hydrogen Storage

The high cost of materials, particularly carbon fiber, is the primary cost driver in hydrogen storage composite tank technology. These costs can be reduced by improving materials and systems and moving to higher volume manufacturing processes using advanced manufacturing R&D. Cycle time reductions, filament winding process advancements, a reduction in the amount of fiber used through strategic fiber placement, and improvements in resin matrix technologies are all examples of manufacturing related R&D which can greatly lower hydrogen storage costs.

Hydrogen Production and Delivery

Currently, hydrogen production is capital-intensive. Widespread adoption of hydrogen fuel cells requires consumers to have access to cost-competitive hydrogen. Steam methane reforming of natural gas in centralized production facilities is projected to meet the DOE cost goal of less than $4/gge at high production volumes, but there are opportunities for lowering the manufacturing costs of building hydrogen fueling stations. Additionally, reliability issues in manufactured components and systems cause the overall cost of compression to be high.

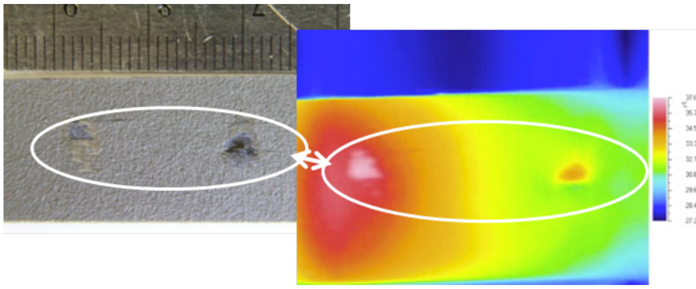

Figure 2. Example of infrared thermographic detection of gas diffusion media defects (surface scratches) using direct current excitation. The sample is shown on the left and the detected thermal response, with the material moving at 30 foot per minute, is shown on the right.

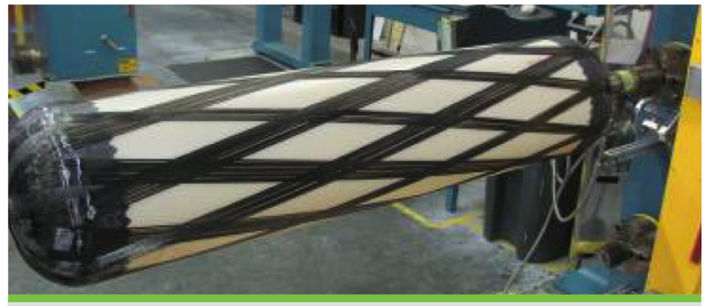

Figure 3. Example of a hydrogen storage pressure vessel showing forward and aft dome caps that were filament wound during the manufacturing process.

Cross Cutting

Cross cutting activities such as manufacturing process simulation, quality control, and metrology must be developed for the full suite of hydrogen and fuel cell related manufacturing processes. Process simulation can help to establish manufacturing process requirements (e.g., tolerances and quality assurance requirements), reduce manufacturing costs by relaxing noncritical tolerances, cut development times by generating more robust designs, and facilitate optimal solutions. Low-cost quality control technologies are needed to increase the reliability and quality of manufactured products. Non-destructive, in-line metrology techniques must be developed to reliably measure various process quantities such as microstructure defects, catalyst loading levels, surface roughness, coating quality, and dimensional accuracy.

Success Stories

Projects previously supported by the Manufacturing R&D program have resulted in significant manufacturing advancements.

Examples of these advancements include:

- Demonstrated in-line techniques able to detect defects in web-lines of catalyst coated membranes, gas diffusion layers (GDL), and membranes at speeds of 30 ft/min (see Figure 2).[1]
- Reduced the cost and increased the throughput of GDLs by 50% and 400% respectively since 2008.[2]
- Demonstrated the ability to bond membrane layers in less than 1 second using ultrasonic bonding techniques (compared to 1 minute when using traditional hot pressing).[3]
- Reduced the cost and weight of hydrogen storage composite tanks by more than 15% using advanced fiber placement manufacturing techniques (see Figure 3).[4]

Goals

- Develop manufacturing techniques to reduce the cost of automotive fuel cell stacks at high volume (500,000 units/year) from the 2008 value of $38/kW to enable a $40/kW system cost by 2020.
- Develop fabrication and assembly processes to produce compressed hydrogen storage systems that cost 12% less than the current high-volume value of $17/kWh for widespread commercialization of hydrogen fuel cell electric vehicles across most light duty platforms by 2017.
- Support efforts to reduce the cost of manufacturing components and systems to produce hydrogen at less than $4/gge (untaxed, delivered, and dispensed at high volumes) by 2020.

For More Information

More information is available from the proceedings of the Hydrogen and Fuel Cell Manufacturing R&D Workshop which was held by DOE and NREL with various manufacturing stakeholders from the federal government, universities, national laboratories, and industry. Additional details about current FCTO activities are presented in the Manufacturing section of the Office's Multi-Year Research, Development, and Demonstration Plan.

References and Notes

1. http://www.hydrogen.energy.gov/pdfs/progress12/vi_1_ulsh_2012.pdf
2. http://www.hydrogen.energy.gov/pdfs/review11/mn002_morgan_2011_o.pdf
3. http://www.hydrogen.energy.gov/pdfs/review09/mf_05_puffer.pdf
4. http://www.hydrogen.energy.gov/pdfs/review13/mn008_leavitt_2013_p.pdf

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