

III.A Compressed/Liquid H₂ Tanks

III.A.1 Low-Cost, High-Efficiency, High-Pressure Hydrogen Storage

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Subcontractors:

FEA Technologies, Dana Point, CA

Objectives

- Design and develop low cost on-board hydrogen storage system to achieve 2005 DOE storage targets.

Technical Barriers

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

- A. Cost
- B. Weight and Volume
- H. Sufficient Fuel Storage for Acceptable Vehicle Range
- I. Materials

Approach

Quantum will be using 10,000-psi compressed hydrogen storage tanks to achieve the DOE hydrogen storage technical targets. Techniques to be explored include:

- composite design and process optimization to improve weight efficiency and reduce material usage,
- imbedding sensors to monitor cylinder health and reduce material usage (therefore lower weight and cost), and
- cooling hydrogen to increase energy density.

The goal in Phase I of the project is to produce development tanks that reduce the amount of composite materials required without sacrificing safety through design and process optimization. Since the tank is a significant portion of the system weight, the optimization efforts will also improve system level efficiency.

Accomplishments

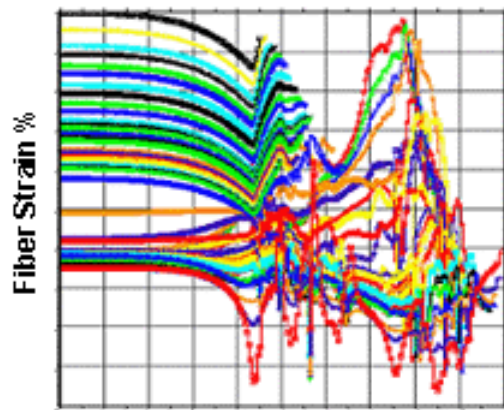
- Preliminary test results indicate that a refueling rate of 2 kg H₂/min is highly possible.
- Baseline 10,000-psi tank using current technology designed, fabricated, and tested for reference information.

Fiber	# of Filaments	Tensile Strength		Tensile Modulus		Approx. Dry Fiber Cost (\$/kg)
		ksi	MPa	ksi	Gpa	
High Performance	12K	900	6,370	42.7	294	\$170
Mid Performance	18K	790	5,490	42.7	294	\$54
Low Cost	24K	711	4,900	33.4	230	\$20

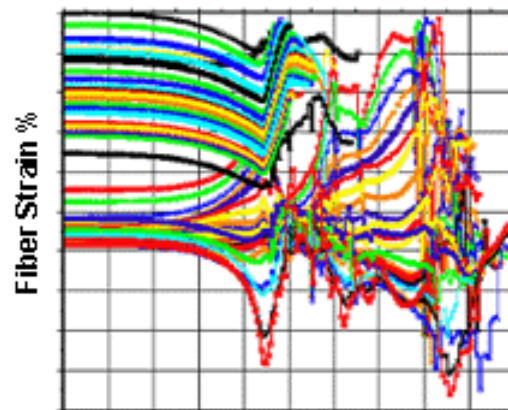
- 10,000-psi tank designed, fabricated, and tested with 58% to 68% fiber translation using low cost carbon fiber.

Future Directions

- Evaluate three other techniques for reducing the amount of fiber required and increasing the fiber translation to 78% to 85%.
 - Vacuum bagging
 - Autoclave curing
 - Using composite wafers



Baseline Design



Optimized Design

- Develop a sensor system integrated into the composite to monitor tank health and reduce the required burst safety factor. Potential technologies to explore include:
 - Resistance strain gauge monitoring
 - Fiber optic strain gauge monitoring
 - Acousto-ultrasonic monitoring
- Investigate through analysis the storage of hydrogen at lower temperatures to increase density. A thermal FEA model will be developed to simulate charging and discharging of the tank at low temperatures.

Introduction

There is a strong demand in the automotive market for cost-effective and efficient high-pressure hydrogen storage systems. The world's premier automotive original equipment manufacturers (OEMs) developing fuel cell vehicles have demonstrated significant interest in this technology. The currently validated Quantum TriShield™ tank technology is close to meeting the percent weight, energy density, and specific energy goals of 6% hydrogen by weight, 1500 W-h/L, and 2000 W-h/kg of the DOE's FreedomCAR initiative. However, the current product line utilizes premium "aerospace-grade" carbon fiber reinforcement to meet the challenging structural requirement of supporting over 23,500 psi burst pressure as specified in current regulations. The carbon fiber cost is too high to achieve the cost goal of \$5 per kW-h, even if significant raw material cost reduction due to economies of scale is taken into account.

Approach

The focus of this project is to meet the cost goal of the DOE hydrogen storage technical targets. Quantum's current 10,000-psi TriShield™ tank technology is close to meeting many of DOE's targets, but the cost is still a major issue. Since the carbon fiber cost is a large portion of the overall cost, the approach is to reduce the amount of carbon fiber needed to build the storage system while maintaining

equivalent levels of performance and safety. This will be accomplished by improving the fiber translation using non-conventional filament winding processes and integrating sensors to actively monitor tank health. Reducing the amount of fiber used may also reduce the overall weight of the system. An evaluation of lower-cost fibers that could deliver the same performance will also be considered.

Results

Quantum is in the initial stages of this DOE project. Two of the factors that contribute to a lower fiber translation are laminate quality and void content. Preliminary test results show that improving void content through the wet wind process can yield an 8% increase in burst strength compared to winding with prepreg fiber. Also, Quantum has been able to demonstrate a 10,000-psi tank using low cost commercial-grade carbon fiber instead of the more expensive and higher performing aerospace-grade fibers. These promising results are a positive indication of Quantum's ability to lower the cost of a 10,000-psi hydrogen storage system and meeting the project objectives.

Conclusions

It is too early in the project to draw any formal conclusions since a significant portion of the work is still on-going. However, preliminary results indicate that the estimated potential cost savings are within reach.