VI.5 Continuous Fiber Composite Electrofusion Coupler

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Subcontractors:
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- Savanah River National Laboratory, Aiken, SC

Project Start Date: December 1, 2015
Project End Date: November 30, 2018

Overall Objectives

- Quantify
  - Various mechanical characteristics of coupler: burst strength, axial strength, leak rates, and fatigue characteristics.
  - Manufacturing costs of coupler.
- Optimize
  - Mechanical design of composite coupler: maximize strength characteristics while constraining costs.
- Demonstrate
  - Coupler without mechanical components, which would be subject to hydrogen embrittlement.
  - Manufacturability of a coupler that reduces cost and complexity of hydrogen pipeline installation.
  - Advanced electrofusion coupler meets mechanical requirements for pipeline designed to transport hydrogen at 225 bar.

Fiscal Year (FY) 2016 Objectives

- Quantify
  - Initial mechanical properties of coupler: burst strength, axial strength, and leak rates.
  - Heat and electrical requirements to electrofuse the coupler.
  - Design lengths for coupler based on mechanical requirements.
  - Manufacturing costs for the coupler.
- Optimize
  - Design of mechanical fit between various layers in the coupler, and the dimensions of the modified pipe ends. Decreasing tolerances bring potentially better design but also increased costs and reduced ease of manufacturing. This must be optimized.
- Demonstrate
  - Manufacturability of coupler with particular focus on fiber placing wire to form an electrofusion bond.

Technical Barriers

This project addresses the following technical barrier from the Hydrogen Delivery section of the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan.

(D) High As-Installed Cost of Pipelines

Contribution to Achievement of DOE Hydrogen Delivery Milestones

This project will contribute to achievement of the following DOE milestones from the Hydrogen Delivery section of the Fuel Cell Technologies Office Multi-Year Research, Development, and Demonstration Plan.

- Milestone 1.5: Coordinating with the H_2 Production and Storage sub-programs, identify optimized delivery pathways that meet a H_2 delivery and dispensing cost of <$2/gge for use in consumer vehicles. (4Q, 2020)
- Milestone 6.3: By 2020, reduce the cost of hydrogen delivery from the point of production to the point of use in consumer vehicles to <$2/gge of hydrogen for the gaseous delivery pathway. (4Q, 2020)

FY 2016 Accomplishments

- Refined and developed the design specification for the coupler including mechanical loading, environmental effects, and leak rates.
- Designed, manufactured, and tested electrofusion coupons with continuous fiber composite, establishing baseline bond strength expectations for adjacent coupler components.

- Designed, manufactured, and tested the wire placement process for use on this particular design of coupler. This is a baseline for future work.
- Completed an evaluation of appropriate adhesives for use in the coupler. Down-selected to top adhesive and short list of backup options.

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INTRODUCTION

Past pipe couplers employed steel components in sealing mechanisms that were subject to hydrogen embrittlement. This coupler will focus on nonmetallic solutions by way of electrofusion (heat via electrical current) of two adjacent cylindrical plastic surfaces. A backup solution is present, which uses mechanical couplings; however the steel would not be exposed to hydrogen. This will enable low maintenance costs of composite pipelines to hit hydrogen delivery price targets set in milestones above.

APPROACH

This research draws from existing electrofusion pipe coupling technology, but extends to be suitable for use on a variety of materials available for composite pipelines. Automated Dynamics' technology is well-suited to couple thermoplastic bonded pipes (where each of the pipe's radial adjacent layers are bonded to each other), by our fiber placement technology that bonds continuous media (fiber reinforced composite, plastic coated wire) on the fly without need for post-curing. Coupler designed in this project shall be available for such pipes, and for nonbonded pipes. Existing electrofusion couplers do not allow continuous fiber composite reinforcement necessary to achieve high pressures sought by the DOE. Our coupler will employ this continuous fiber thermoplastic composite as the structural layer for high pressures and high induced axial loads.

RESULTS

Results to date have centered on design of the coupler and preliminary lab-scale tests. Lab-scale tests have established electrofusion processes to be used on the coupler prototypes. Prototypes are being manufactured presently and will be tested in the third quarter of 2016.

CONCLUSIONS AND FUTURE DIRECTIONS

Initial results year to date (July 2016) indicate the technology is suitable to meet the goals of the DOE program and specific milestones above. The coupler requires a high degree of precision and the automated manufacturing processes established and refined over 30 years at Automated Dynamics have yielded such precise components. For example, the wire embedded in the coupler used for electrofusion must be manufactured at a very consistent and precise diameter to fit with adjacent components. Similarly, repeatability is achieved through automated fiber placement which allows the reliability required for the demanding specifications of a hydrogen delivery pipeline.