Fiber-Reinforced Polymer Hydrogen Pipelines

Novel Pipeline Materials Offer Safer, More Reliable, and Economic Alternative to Steel

Background
Gas pipelines are presently the most feasible option for transmitting large quantities of hydrogen over long distances, and pipeline transmission is expected to be the means by which hydrogen is delivered from large-scale, centralized or distributed production plants to fueling stations. However, the existing hydrogen pipeline technology cannot achieve the cost and performance goals required for successful implementation of transmission and distribution networks.

Existing steel pipelines are subject to hydrogen embrittlement which poses numerous technical and economic issues. In addition, welding technology for steel pipelines is costly and can exacerbate embrittlement. Hydrogen leakage and diffusion pose significant challenges for designing pipeline equipment, materials, seals, valves and fittings. In addition, hydrogen delivery infrastructure will rely on sensors and robust designs and engineering. Fiber-reinforced polymer (FRP) pipeline technology has the potential to overcome these barriers, enabling reductions in pipeline installation costs and providing safer, more reliable hydrogen delivery.

The initial phase of the project involves investigating FRP spoolable pipelines under development for the oil and gas industry. The challenge is to evaluate the materials necessary to successfully adapt the FRP spoolable pipeline to high-pressure hydrogen use, to determine the necessary modifications to existing codes and standards, to validate the safe and reliable implementation of the pipeline, and to assess the availability of sensor technology that ensures safe and reliable use.

Technology
The construction of FRP piping is typically an inner non-permeable barrier tube, a protective layer over the barrier tube, an interface layer over the protective layer, multiple glass or carbon fiber composite layers, and outer pressure barrier layer.

Cable Winder
(Photo provided by Fiberspar LinePipe, LLC)
The FRP pipe possesses unique anisotropic characteristics that provide improved burst and collapse pressures, increased tensile strength, compression strength, and load carrying capacity, while still remaining sufficiently bendable to be spooled onto a reel in an open bore configuration. FRP pipe can be manufactured with fiber optics, copper signal wires, power cables or capillary tubes installed directly into the structural wall of the piping, which enables the pipe to function as a smart structure.

This project will examine advanced composites for constructing non-metallic hydrogen pipelines and new polymers for use as hydrogen gas barriers.

Accomplishments
• Capital cost projections for FRP pipelines for hydrogen service are close to the DOE technical targets for 2017.
• Long term hydrogen exposure testing of commercial FRP pipelines is in progress.
• Assessment of linear leak rates is in progress, and methods for reducing hydrogen permeability are being evaluated.

Benefits
Improved composite materials and polymers for gas barriers can provide major performance improvements and cost reductions in pipeline construction, enabling achievement of delivery technical targets.

Points of Contact
Barton Smith, 865-574-2196, smithdb@ornl.gov
T. Armstrong, 865-574-7996, armstrongt@ornl.gov

FRP pipelines consist of an inner thermoplastic pressure barrier that is reinforced by helical windings of high-strength glass fiber yarns embedded in an epoxy thermoset resin matrix.