Hydrogen, Fuel Cells & Infrastructure

Materials Solutions for Hydrogen Delivery in Pipelines

Novel Materials to Minimize Hydrogen Embrittlement during High Pressure Transport

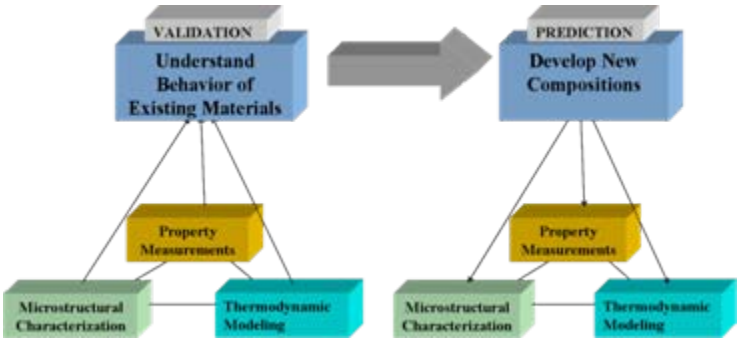
Background

Pipeline transmission is the most economical method for hydrogen delivery in large quantities from the point of generation to point of use. As transmission pressures are increased, steel pipelines that could be used for the transport of hydrogen at low pressures may become prone to hydrogen embrittlement at the welds, the heat-affected-zone and/or the base metal regions in the pipeline. Research to-date clearly shows that hydrogen embrittlement of pipeline steels is one of the limiting factors in the cost-effective, high-pressure transport of hydrogen.

Technology

Recently, significant advances have been made in understanding the mechanisms of hydrogen embrittlement in a wide variety of materials and in materials technologies. The increasing integration of computational techniques with experimental methods has resulted in the development of "designer" materials along with the scientific methodologies for developing customized materials better suited for any given application. New coating materials and coating technologies hold promise in developing barrier coatings to minimize the dissolution and hence the permeation of hydrogen through steels. The work on this project represents an integrated approach to developing and testing new materials solutions to enable pipeline delivery of hydrogen at high pressures.

The scope of the project includes (1) identification of steel compositions and associated welding filler wires and processes that would be suitable for new pipeline infrastructure for transport of hydrogen at requisite high pressures, (2) development of barrier thin film coatings that would minimize the hydrogen permeation in the hydrogen pipelines, and (3) understanding the cost factors related to the construction of new pipelines and modification of existing pipelines and to identify the path to cost reduction.



Modeling, Microstructural Characterization and Mechanical Property Measurements are being carried out to understand hydrogen embrittlement characteristics of existing steels and to help identification/development of cost-effective alternate materials and processes

This project is in an early stage of development. ORNL has installed laboratory equipment for *in-situ* mechanical testing of materials under high hydrogen pressures. This equipment includes traditional mechanical testing equipment for tensile strength and fatigue properties. ORNL will also determine the microstructures of these materials. The correlations between microstructures and mechanical properties then can be used to help predict the desirable compositions and microstructures of proposed alternative alloys. ORNL has also provided an infrared heating furnace for use in processing of coatings.

Coating trials are currently being carried out at ORNL with an IR furnace capable of surface heating of samples.

Tensile and fatigue tests will be carried out in-situ in a high-pressure hydrogen atmosphere using ORNL facilities.

Benefits

- Embrittlement-resistant pipeline materials will reduce capital costs of pipeline infrastructure for hydrogen delivery
- Improved pipeline materials will improve the safety and increase reliability of hydrogen delivery by pipeline

Future Work

Future tasks for this project will include the identification and evaluation of alternative steels with the potential for improved resistance to hydrogen embrittlement. Evaluation of coatings designed to minimize permeation of hydrogen will undertaken. The final project phase will involve a financial analysis of the economics of using the newly developed alloys and coatings, and the incorporation of these materials into Codes and Standards.

Points of Contact

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