PROJECT facts

U.S. Department of Energy
Office of Fossil Energy
National Energy Technology Laboratory

Hydrogen and Clean Fuels from Coal

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Experimental Demonstration of Advanced Palladium Membrane Separators for Central High-Purity Hydrogen Production

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Description

The project team of United Technologies Research Center (UTRC), Power & Energy, Inc., and Metal Hydride Technologies, Inc., will confirm the stability and resistance of PdCu trimetallic alloys to carbon and carbide formation and resistance to sulfur, halides, and ammonia (NH_3). UTRC and their research partners will ultimately develop a sulfur-, halide-, and NH_3-resistant alloy membrane for hydrogen separation. The project team will also conduct a techno-economic evaluation of the use of PdCu trimetallic alloy hydrogen separators for central hydrogen production from coal, including an analysis of the optimal system configurations to use with the hydrogen separators. In addition, the project will design the engineering path to construct cost-effective separators for operation at high pressures.

Primary Project Goals

- Develop sulfur-, halide-, and NH_3-resistant PdCu trimetallic alloy membranes and confirm the stability and resistance of PdCu trimetallic alloys to carbon and carbide formation.
- Optimize the membrane to meet the 2010 DOE technical targets of: a hydrogen flux of 200 standard cubic feet per hour per square foot (scfh/ft^2), a hydrogen purity of 99.5%, and an operating capability of up to 400 pounds per square inch gauge (psig) pressure-differential.
- Achieve a project directed target of a 0.1 kilogram per day (kg/day) rate of hydrogen production.
- Complete advanced membrane property simulations by atomistic and thermodynamic modeling calculations.
- Complete a techno-economic evaluation on the use of PdCu trimetallic alloy hydrogen separators for central hydrogen production from coal gasifier fuel gas.

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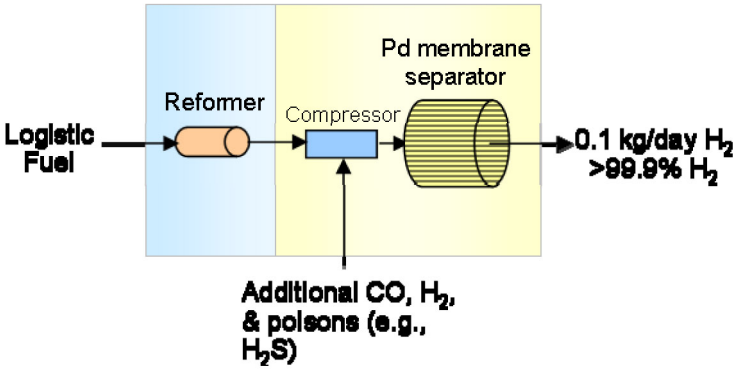
Accomplishments

- Completed advanced membrane property simulations using atomistic and thermodynamic modeling. The modeling showed that the UTRC alloy has increased surface stability with respect to selective element segregation, increased resistance to poisoning by coal gas contaminants, and increased resistance to coke precursor formation.
- Completed design and construction of membrane separators using sulfur-resistant PdCuTM (transition metal) alloys. Ten separators were fabricated and delivered to UTRC for testing. Five separators were constructed with PdCu alloy and the remaining separators were built using the UTRC PdCuTM alloy composition developed under a DOE contract.
- Completed construction work on a new high-pressure testing rig based on coupling a logistic fuel reformer with a membrane testing rig. Evaluated several PdCu alloy separators using the new high-testing pressure rig for hydrogen separation performance.
- Completed initial technical and economic modeling. The initial results indicate that both alloys selected for evaluation should be able to meet the U.S. Department of Energy's (DOE) dense metallic membrane technical targets. The membrane alloys are predicted to be resistant to coke and carbide formation.

Benefits

Trimetallic PdCu alloy membranes appear to have significant advantages over ceramic and polymer membranes in terms of manufacturability, extensive lifetime operation, ease of sealing, higher operating temperatures, and selectivity for hydrogen. The project team will demonstrate, at a laboratory scale, the performance, stability and durability of advanced trimetallic PdCu alloy membrane separators for high-purity hydrogen production. The possible implementation of trimetallic PdCu alloy membranes into power plants could have a major impact on America's energy needs by delivering an abundant, economical supply of hydrogen produced from coal with near-zero environmental emissions.



Schematic of Testing Layout

Image of H_2 Separator