Scale-Up of Hydrogen Transport Membranes for IGCC and FutureGen Plants

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PD009

Overview

Timeline

- Phase I Start Oct. 1, 2005
- Phase II Start Oct. 1, 2009
- Phase II End June 2012
- ~70% Complete

Budget

- Total project funding: $7,915,802
  - DOE Share: $6,332,642
  - Contractor Share: $1,583,160
- FY09 funding: $1,875,000
- FY10 funding: $2,500,000

Barriers Addressed

- Reducing hydrogen cost
- Membrane durability
- Membrane testing & analysis

Partners

- Project Lead: Eltron R&D
- Partners: Eastman Chemical Co.

Relevance

Overall Program Objectives

- Cost-effective H_2 / CO_2 separation system
- Retains CO_2 at gasifier pressures
- Operates near water-gas shift conditions
- Tolerates reasonably achievable levels of coal impurities

Objectives June 2009 – May 2010

- Membrane manufacturing – Scale-up
- Lifetime testing
- Impurity testing
- Design of 12 lbs/day membrane reactor

Technical Approach

- Materials Development
  - Examine membrane and catalyst compositions
  - Develop preparation techniques
- Performance Screening
  - Evaluate flux, life, impurities effects using WGS composition
  - Establish range of operating conditions
- Mechanical Design
  - Assess strength of materials, embrittlement, welding techniques, flow dynamics
  - Address manufacturing costs and maintenance issues
- Process Design and Economics
  - Integrate into IGCC flow sheets – with and without co-production of H_2 & power
  - Determine methods for impurity management
  - Compare process economics versus other technologies
- Scale-up steps
  - 12 lbs/day H_2 production – coal-based syngas slipstream
  - 250 lbs/day H_2 production – coal-based syngas slipstream + WGCU

Approach - Milestones

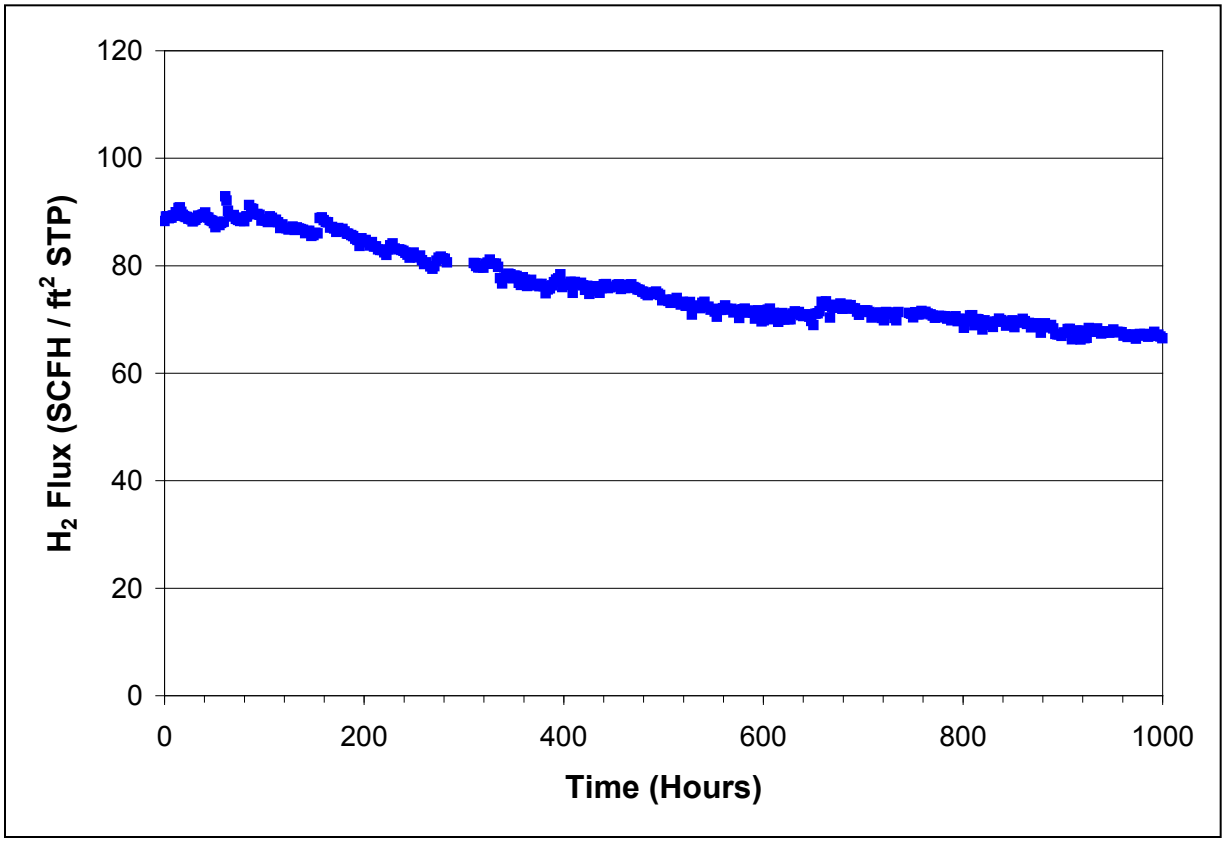
	Milestone
FY09 Q3	Procure membrane materials prepared by different manufacturers and processes for testing and evaluation Status: Completed
FY09 Q4	Select the preferred manufacturing process and catalyst deposition technique for scale-up in PDU. Status: Completed
FY10 Q1	Collect lifetime data on a 6” tubular membrane with electrodeposited catalysts. Status: Completed
FY10 Q2	Deposit catalyst on a five foot long tubular membrane. Status: Completed
FY10 Q3	Complete membrane module design and skid layout. Status: In Progress
FY10 Q4	Complete construction of 12 lbs/day unit. Status: In Progress

Technical Accomplishments

- Membrane Manufacturing
  - 100 feet membrane tubing
    - ½” OD
    - 500 μm wall
  - Catalyst deposited on the inside & outside of a 5’ tube

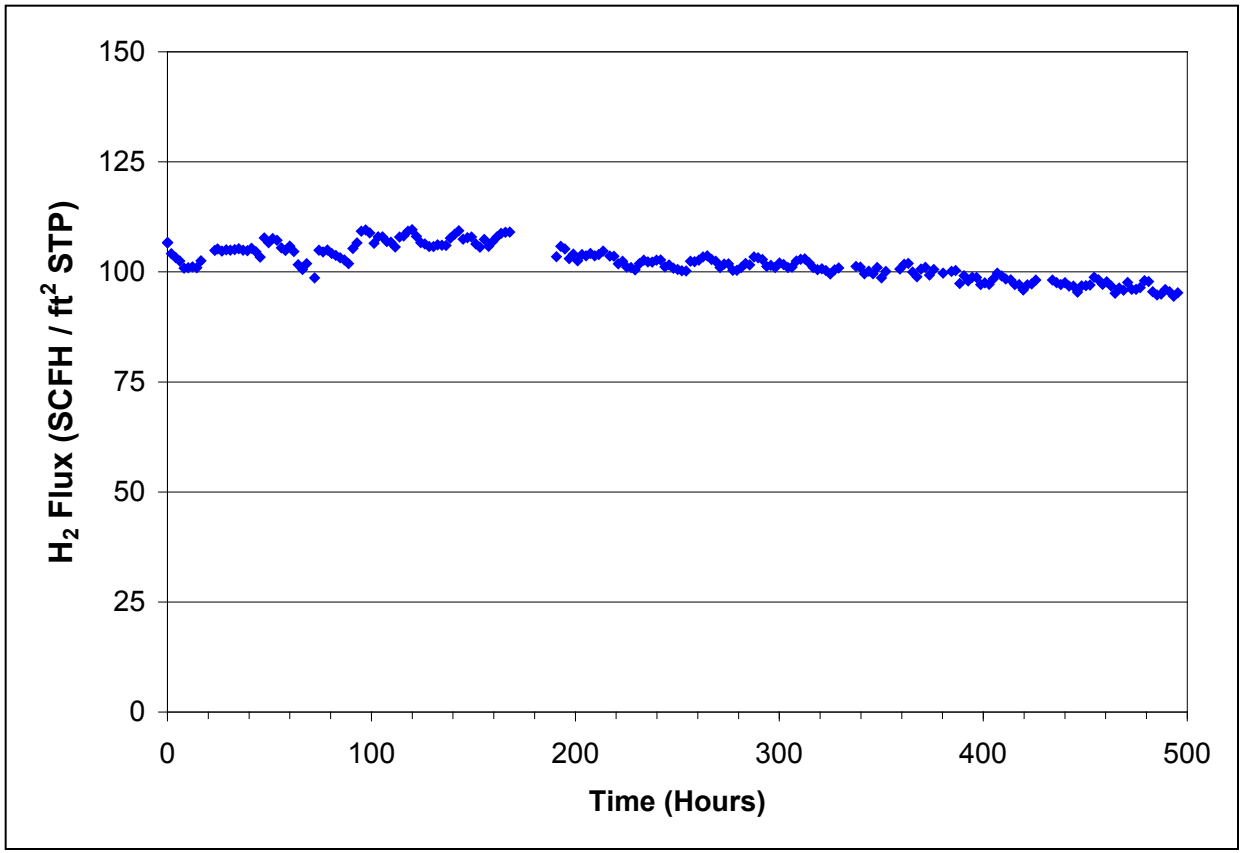
Technical Accomplishments

- Lifetime Testing – Planar Membrane #1
  - NETL Protocol 1
  - 2.5 SLPM (50% H_2, 1% CO, 29% CO_2, 19% H_2O, 1% He)
  - 340°C
  - 185 psig feed / 15 psig sweep
- **Key Issues**
  - Stability of H_2 flux
  - Mass transfer resistance



Technical Accomplishments

- Lifetime Testing – Planar Membrane #2
  - 2.5 SLPM (50% H_2, 1% CO, 29% CO_2, 19% H_2O, 1% He)
  - 340°C
  - 450 psig feed / 50 psig sweep
- **Key Issue**
  - Effect of pressure on membrane stability



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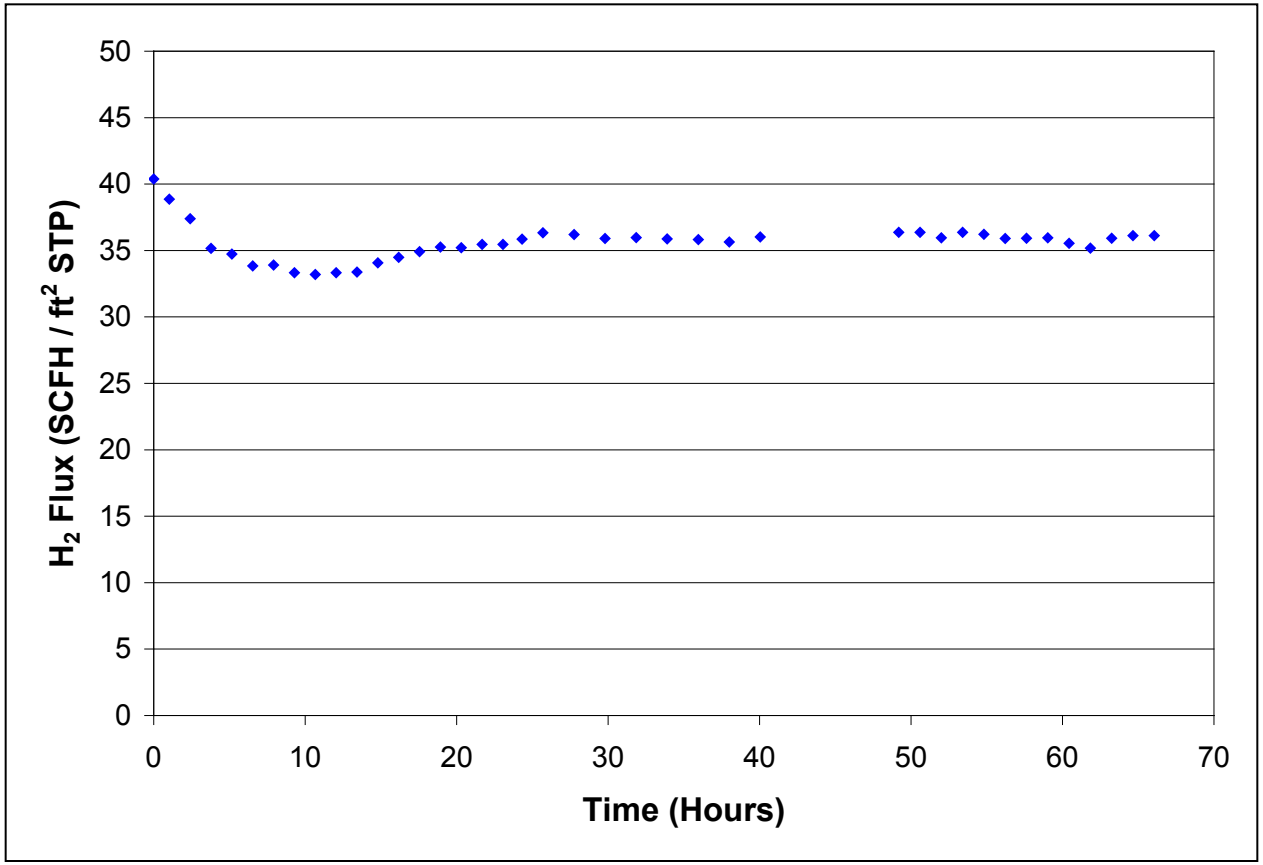
Technical Accomplishments

- Lifetime Testing – 6" Tubular Membrane
  - 3.7 SLPM (50% H_2, 1% CO, 29% CO_2, 19% H_2O, 1% He)
  - 340°C
  - 100 psig Feed
  - 45% H_2 Recovery
- **Key Issues**
  - Mass transfer resistance
  - High feed flow rates needed

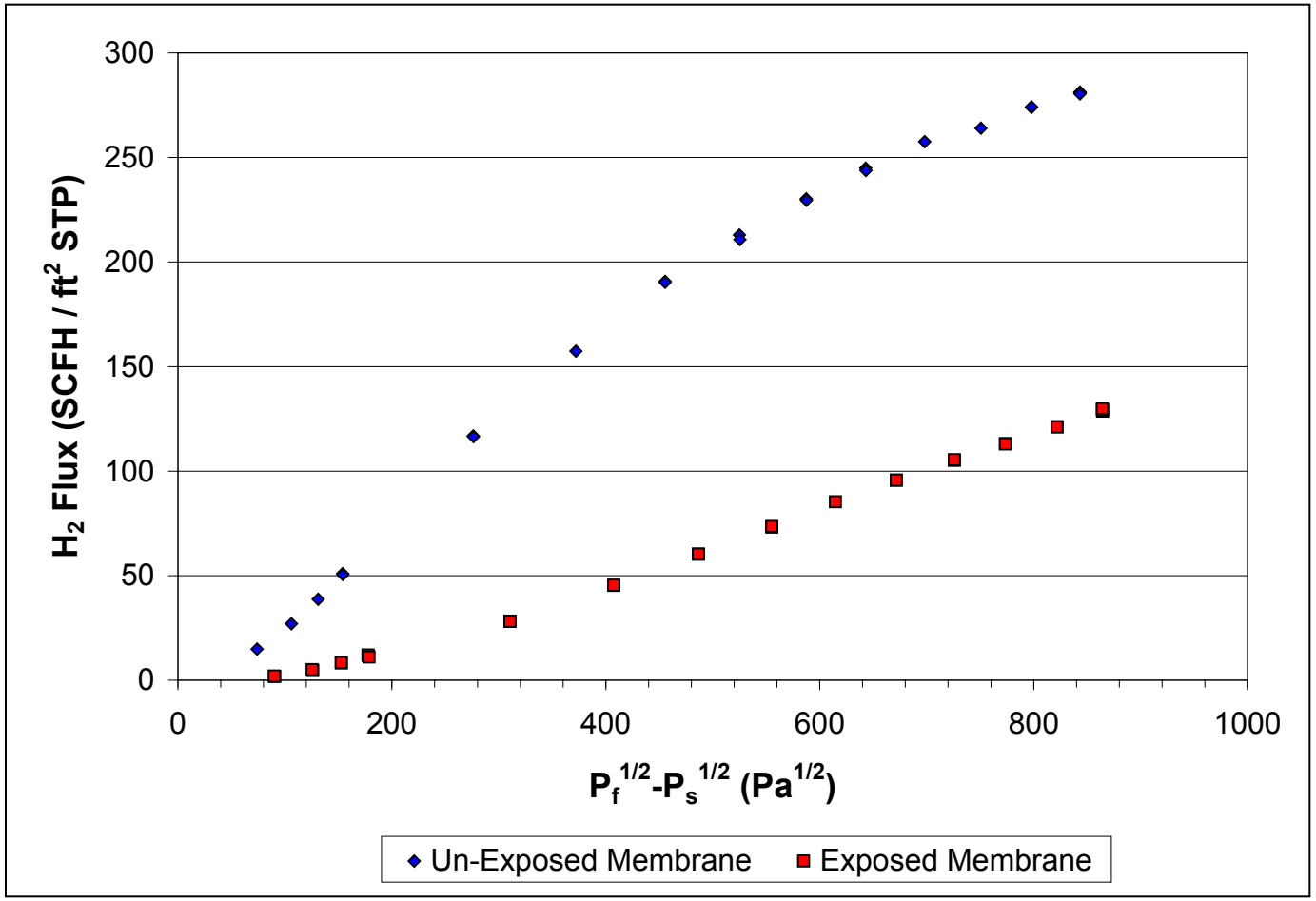


Technical Accomplishments

- Impurity Testing
  - Eltron membranes were exposed to gasified coal syn-gas that was passed through a ZnO sorbent bed
    - 168 hours
    - 340°C
    - 700 psig
    - < 5 ppm H_2S (>35 ppm for ~ 30 minutes)
  - Following exposure membranes were characterized and tested for H_2 flux performance

Technical Accomplishments

- H_2 flux testing following exposure
  - 3.8 SLPM (50% H_2, 50% He)
  - 340°C
  - 300 psig feed
- **Key Issues**
  - Flux drop after exposure to be expected
  - As, Hg, S found on membrane surface



Technical Accomplishments

12 lbs/day H_2 Membrane Reactor

- Design Specification
  - 10’ of ½” OD tubular membrane
  - 450-900 psig feed pressure
  - 300 SCFH coal-derived syn-gas
  - 95% H_2 recovery
- Progress
  - Preliminary Design ✓
  - Preliminary Process Hazards Analysis ✓
  - Detailed Design & Final Approval
  - Construction & Installation (FY10 Q4)
  - Operation (FY11 Q1)

Collaborations

- Eltron Research & Development Inc.
  - Prime Contractor
- Eastman Chemical Co.
  - Subcontractor
  - Gasified coal slip-stream
  - WGCU
- Edison Welding Institute
- Membrane Manufacturers

Future Work

- FY2010 Q3 – FY2011 Q1
  - Design, build, operate 12 lbs/day H_2 Unit
  - Go / No-Go Decision
- FY2011 Q2 – FY2011 Q3
  - Preliminary Design 250 lbs/day H_2 Unit
  - Go / No-Go Decision
- FY2011 Q4 – FY2012 Q3
  - Design, build, operate 250 lbs/day H_2 Unit integrated with WGCU

Summary

- Relevance
  - Cost-effective H_2 / CO_2 separation system
- Approach
  - Demonstrate performance and economics on gasified coal feed streams
- Technical Accomplishments
  - Tubular membrane manufacturing was successfully scaled up
  - Lifetime & impurity testing
- Collaborations
  - New partnership with Eastman Chemical Co.
- Future Work
  - Scale-up testing on gasified coal feed stream
    - 12 lbs/day H_2 membrane unit
    - 250 lbs/day H_2 membrane unit

Supplemental Slides

Eltron's Membrane System

Key Features

- 3-layer, dense metal alloy
  - Self-supporting
  - 100% selective
- CO_2 retained at high pressure
- Operates near water-gas shift temperatures.