



Combined Sorbent/WGS-Based CO₂ Capture Process with Integrated Heat Management for IGCC Systems (FE0026388)

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2018 NETL CO₂ Capture Technology
Project Review Meeting, August 13-17

Project Overview

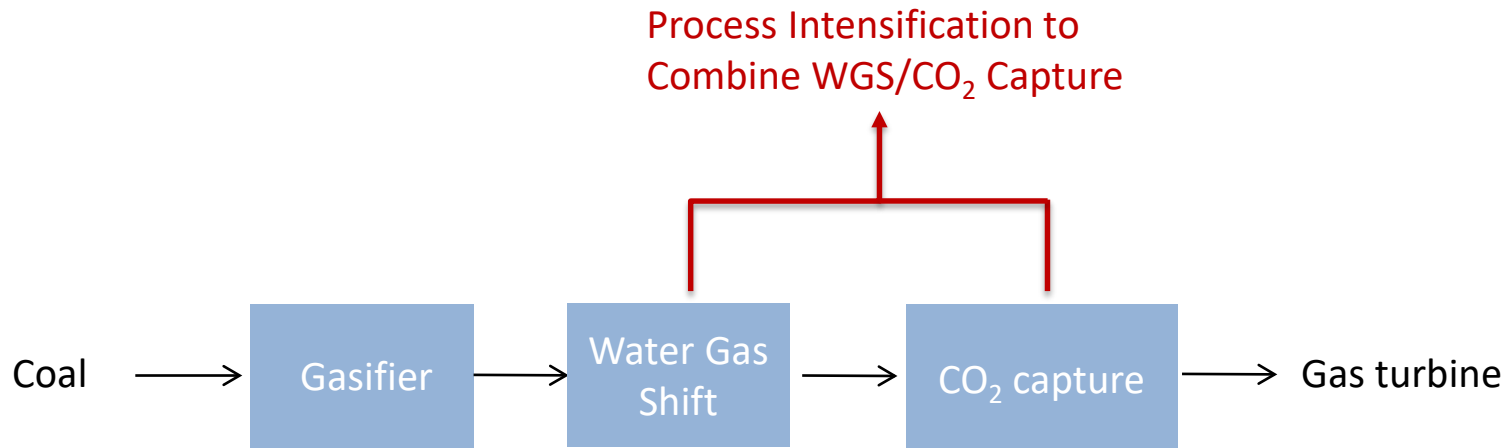
- Southern Research is developing an MgO sorbent-based combined CO₂ capture / water-gas shift (WGS) process for integrated gasification combined cycle (IGCC) power plants.
- Participants and Roles:
 - **Southern Research:** Project lead
 - **IntraMicron:** Heat exchange reactor loading
 - **Nexant:** TEA support



Project Goals

The project seeks to demonstrate at bench-scale:

- **90% carbon capture with 97% CO conversion**
- **Production of 95% pure CO₂**
- **Potential for reduction in cost of electricity for IGCC plants with CO₂ capture**



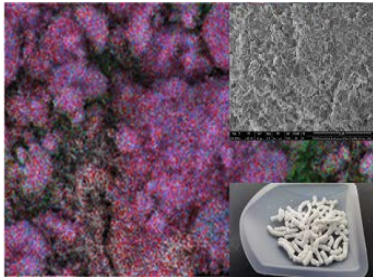
Project Innovations

- Combine a commercial WGS catalyst with a novel magnesium oxide based CO₂ sorbent to capture 90 % + carbon and produce a hydrogen-rich syngas for IGCC
 - Microfiber entrapped catalyst (MFEC) reactor enables high thermal conductivity, both radially and axially, resulting in near isothermal operation
 - Integrated WGS catalyst/CO₂ sorbent reactor enables higher CO₂ partial pressure and corresponding fast capture kinetics
 - Elevated temperature operation results in higher efficiency

Technical Approach

- Period of Performance: Oct 2015 – Sept 2018 (36 months)
 - BP1 (Oct 2015 – Sept 2016): Develop and characterize SR CO₂ sorbent; Separately test performance of WGS catalyst and CO₂ sorbent
 - BP2 (Oct 2016 – Mar 2018): Design and test the combined system in packed bed and MFEC; Evaluate and optimize reactor configurations, preliminary reactor modeling and TEA
 - BP3 (Apr 2018 – Sept 2018): Long-duration run for stability testing, Final TEA report

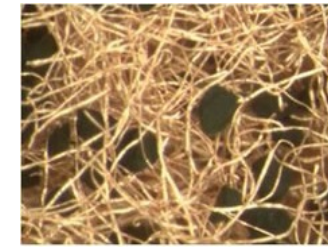
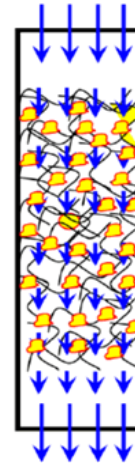
Technical Approach (continued)



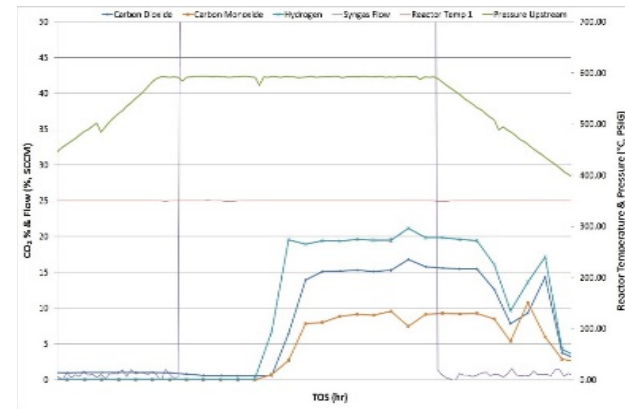
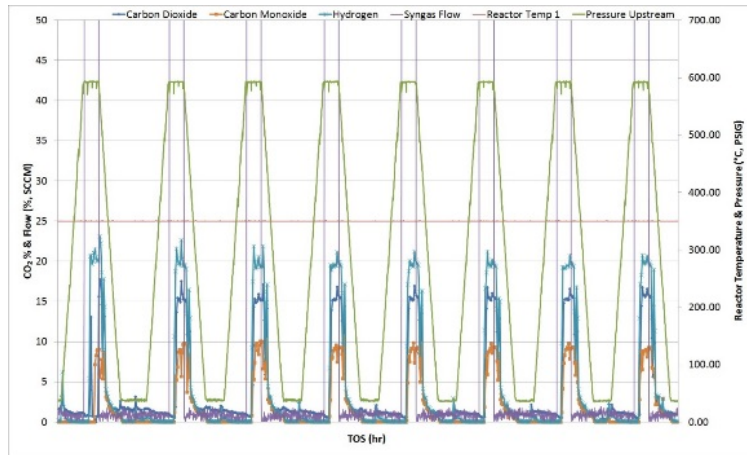
Sorbents

TGA
BET
SEM
EDS

Characterization

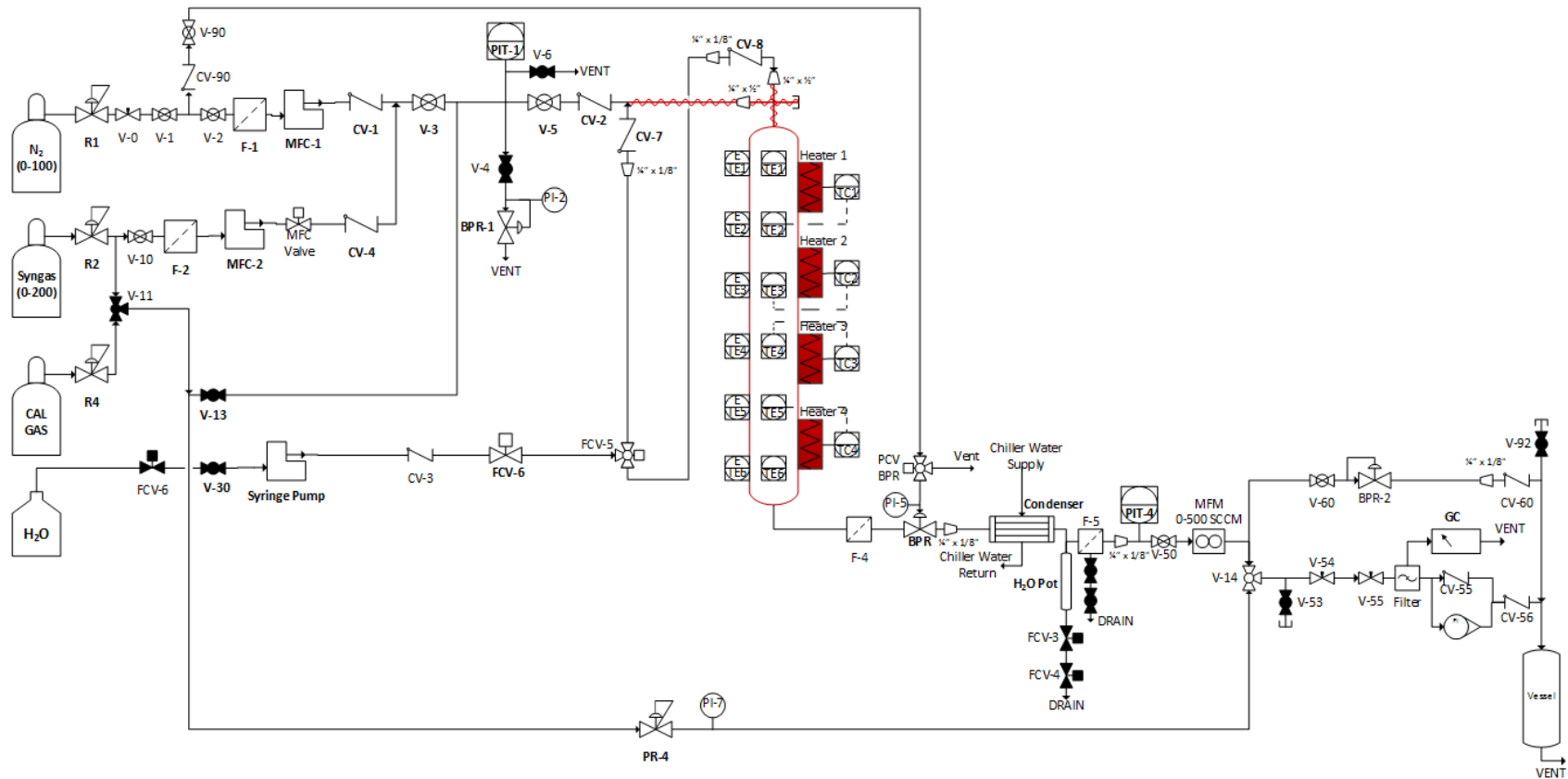


Reactors



Results

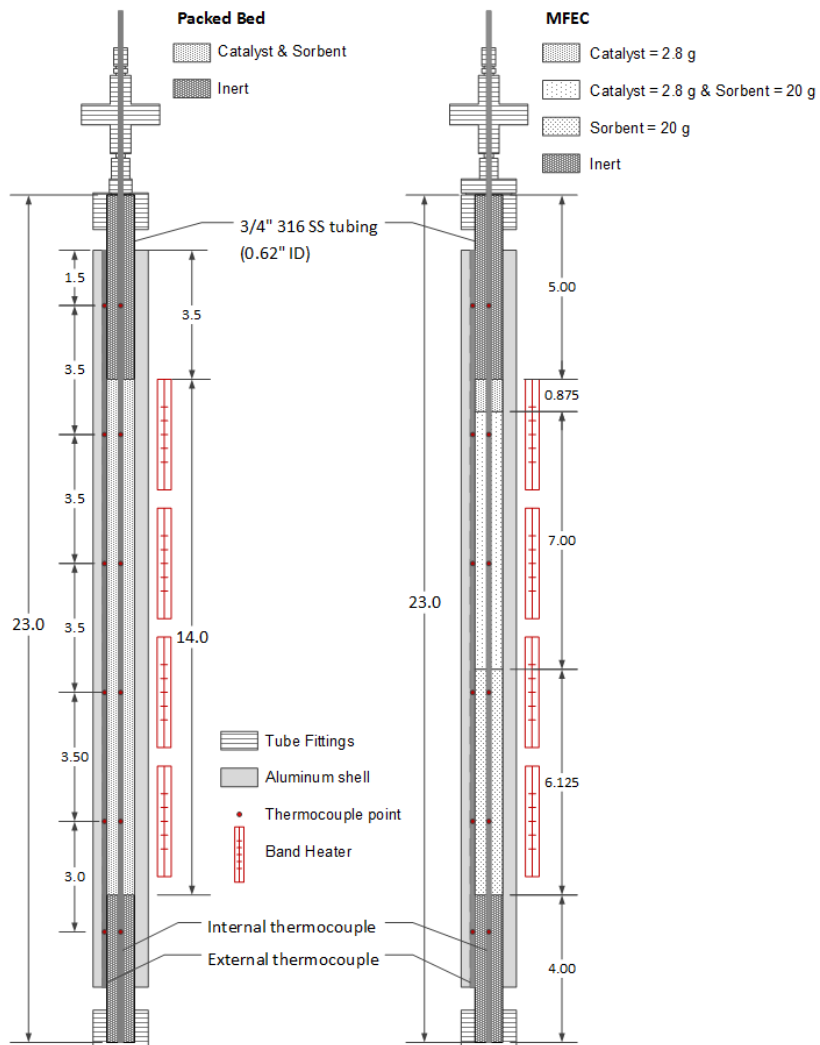
Bench-Scale Reactor System



Summary of Experimental Effort

- Simulated gases used: TRIG and GE
- 15 sorbents prepared; best sorbent (SR 1.3) selected based on TGA and characterization tests; extrudates prepared; reproducibility of preparation demonstrated
- Alternative microfiber materials evaluated in MFEC reactors
- WGS catalyst performance verified over 100 hours at two steam levels
- SR1.3 extensively tested
 - ~2000 cycles in TGA
 - ~800 cycles in separate and combined packed bed reactor (~3000 hours)
 - ~400 cycles in combined MFEC reactor (~1500 hours)
 - Various regeneration schemes evaluated

Reactor Details (MFEC vs. Packed-bed)



	MFEC	Packed-bed
Reactor Size / inch	14* 3/4 (OD)	14* 3/4 (OD)
Sorbent / g	40	15
Catalyst / cc	12	5
Inert Dilute	N/A	SiC
Particle Size / micrometer	50	800

MFEC capable of holding 2.6 times more material in same reactor volume

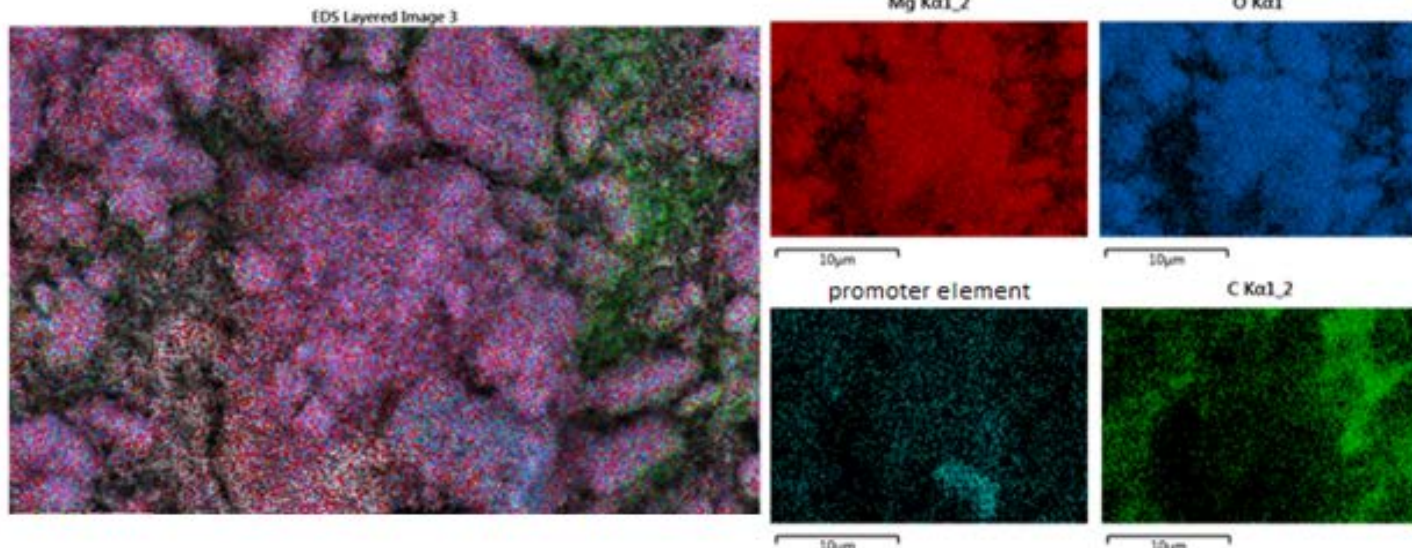
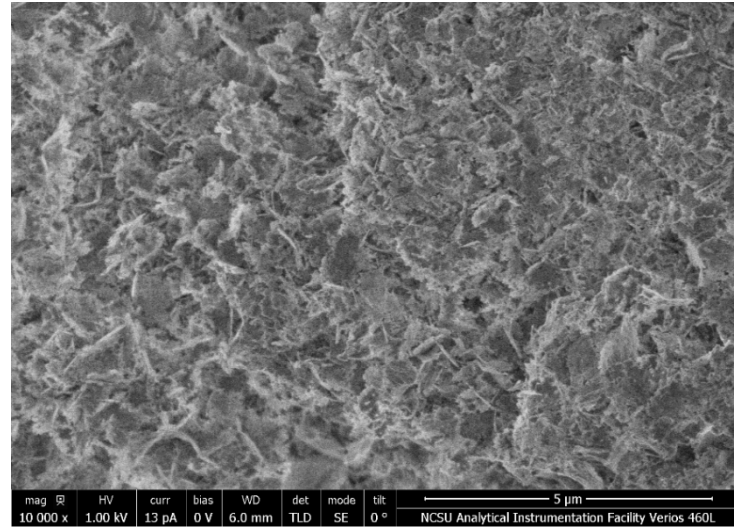
MFEC had <1/2 the temperature variation compared to diluted packed bed

Highlights of Results

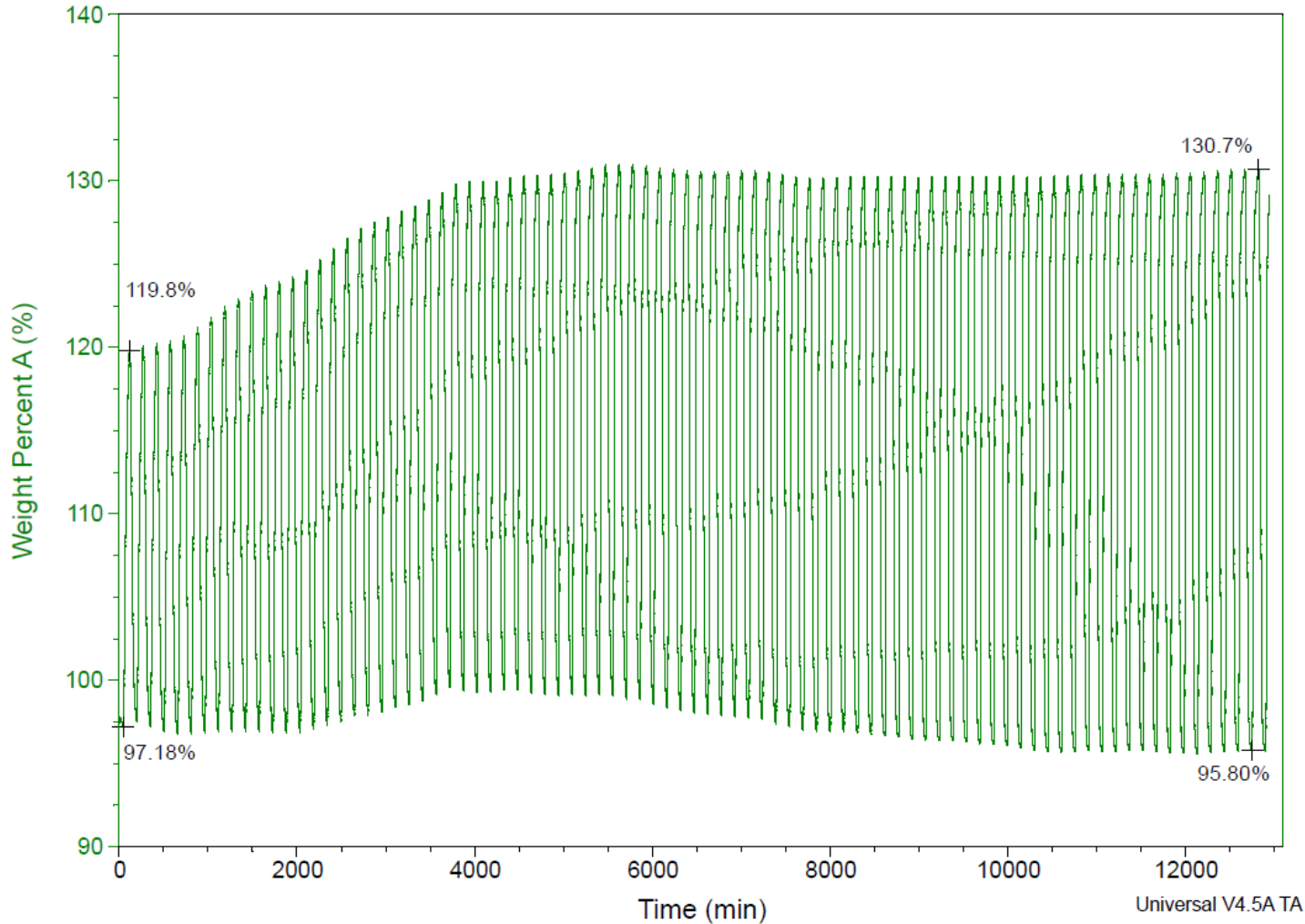
Sorbent Characteristics



SR 1.3 promoted MgO



TGA Sorbent Performance (Mild Regeneration)

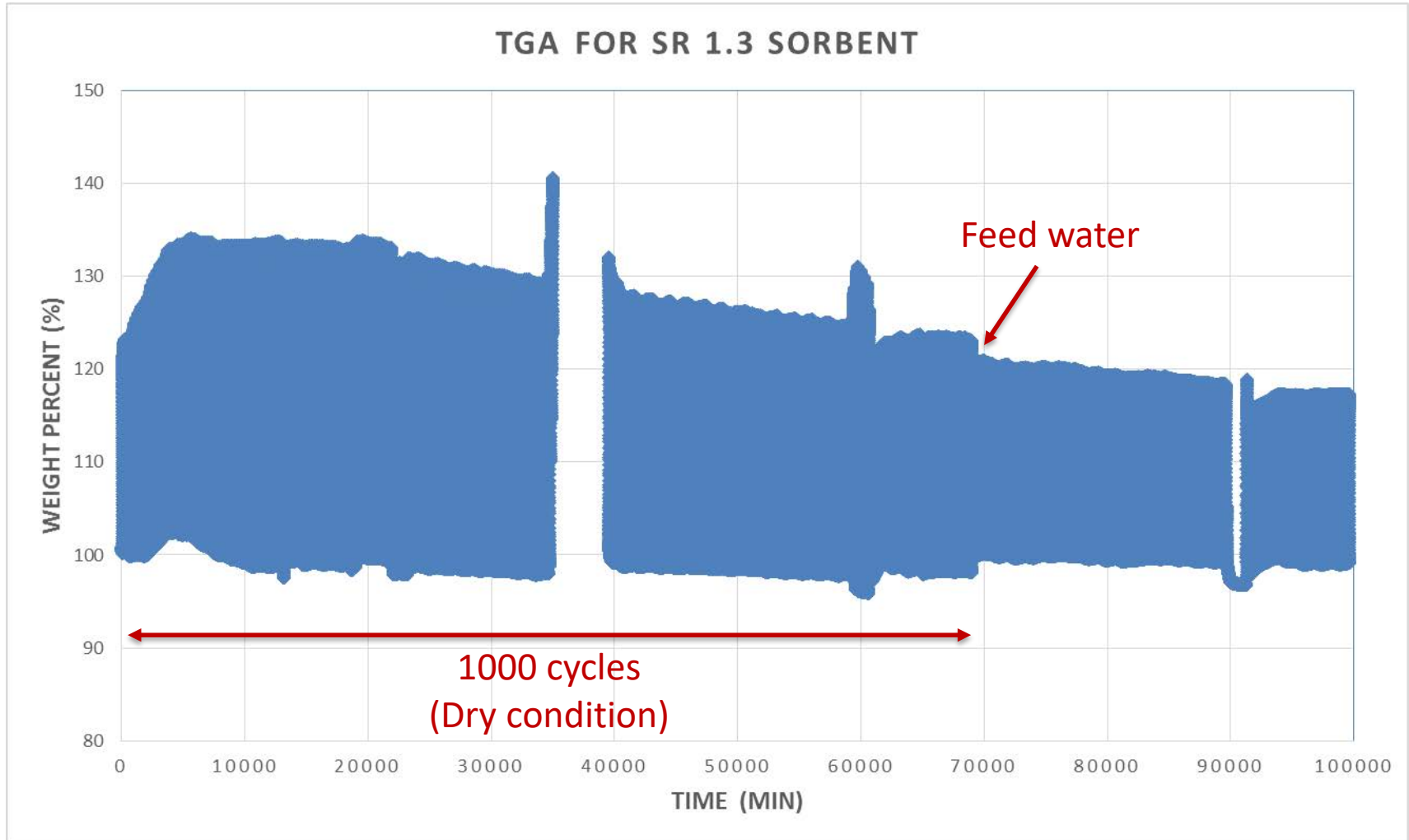


36% weight gain
Over 100 cycles



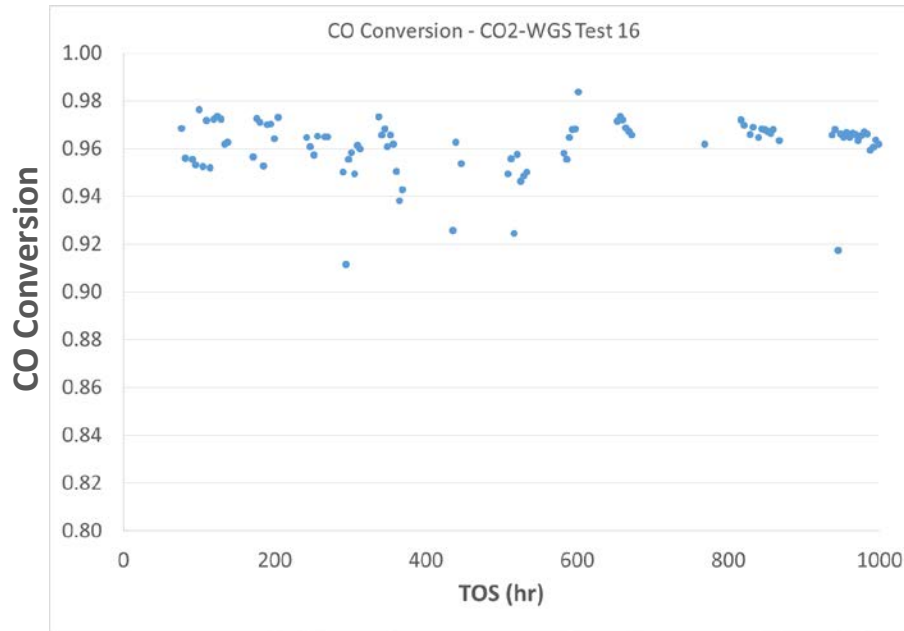
8 mmol/g CO₂
sorbent capacity

TGA Sorbent Performance (Aggressive Regeneration)

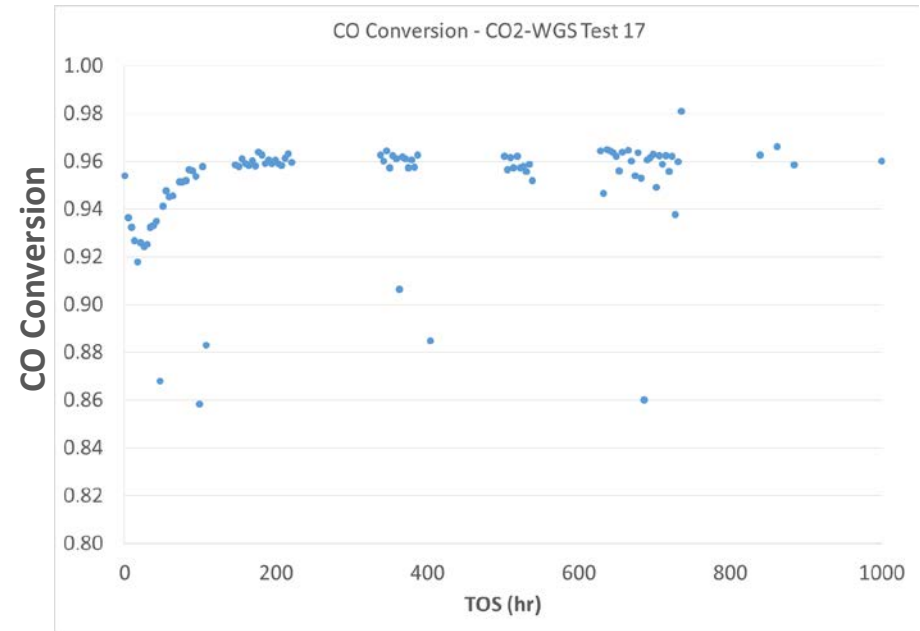


Combined Reactor WGS Performance

(Thermodynamic Limit at Run Conditions (96.5 % CO Conversion))

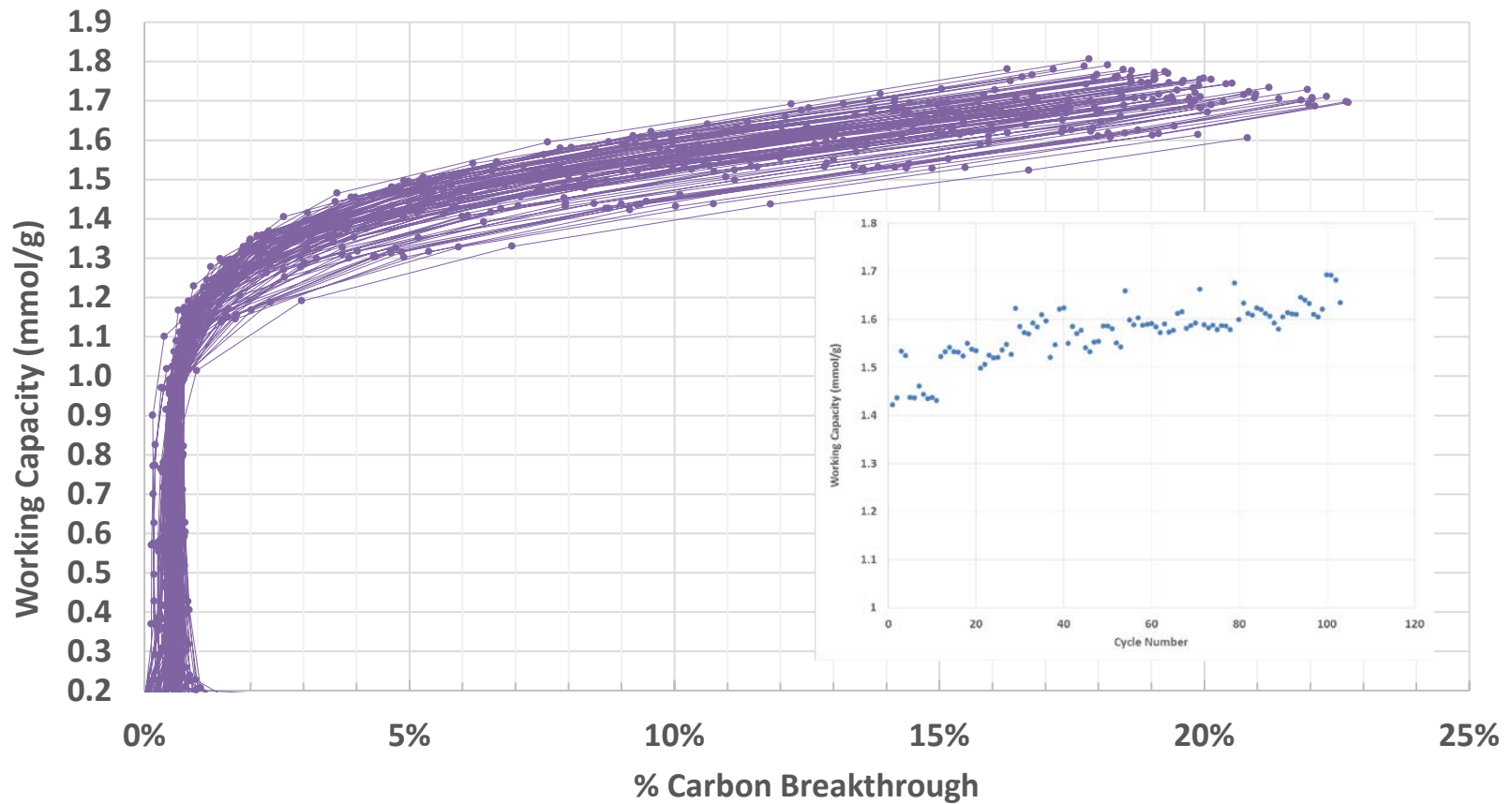


Packed-bed Reactor



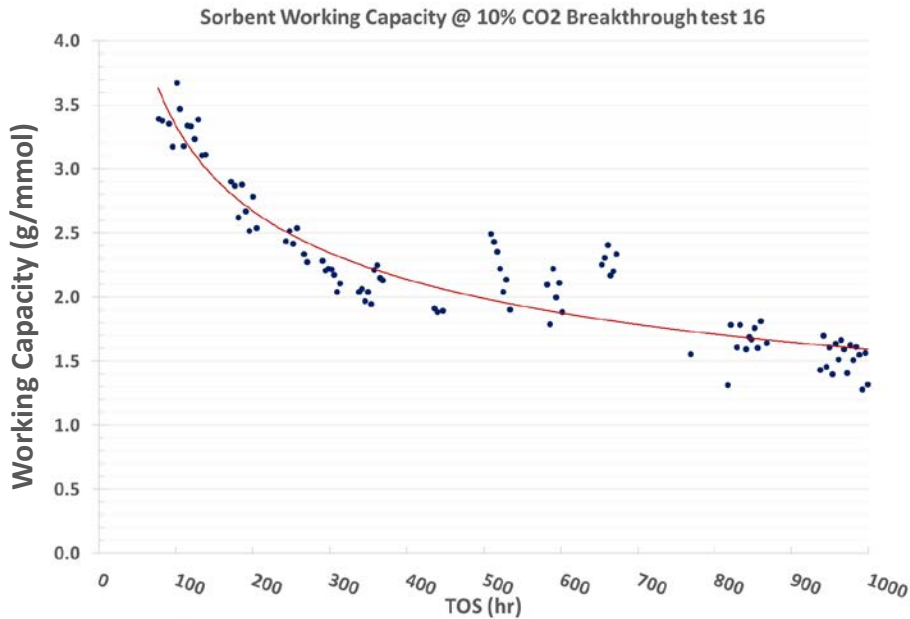
MFEC Reactor

Sorbent Performance (mild regeneration)

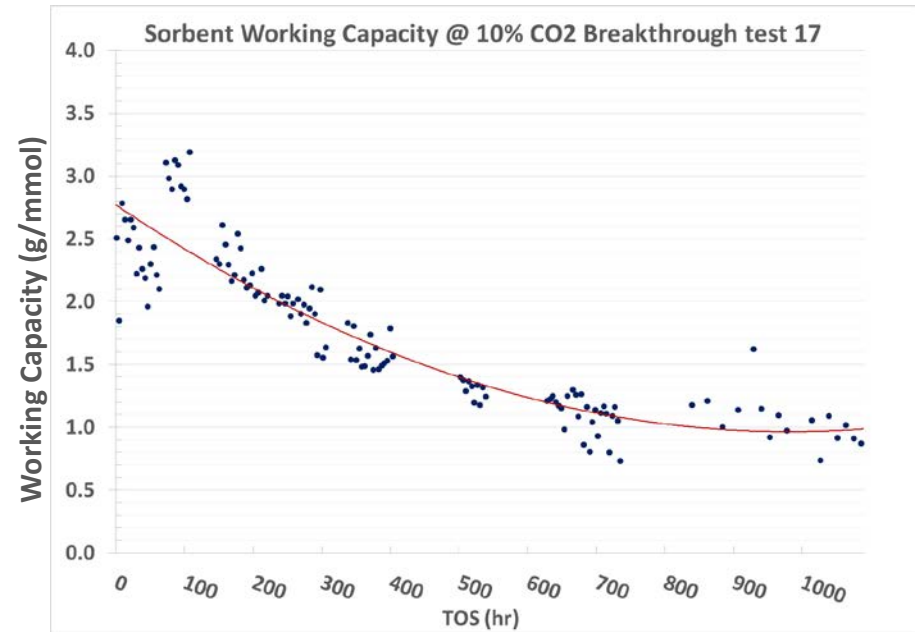


265 cycle test

Sorbent Working Capacity (Aggressive Regeneration)



Packed bed Reactor



MFEC Reactor

Conclusions and Future Work

Conclusions

- A promising CO₂ sorbent with CO₂ capacity over 8 mmol/g has been developed.
- A combined process for WGS and CO₂ capture in a single reactor system has been demonstrated at bench scale
- MFEC reactor has significantly better heat management capability compared to even a highly diluted packed-bed reactor.
- Aggressive regeneration leads to higher CO₂ working capacity but results in lower working capacity when sorbent stabilizes
- Preliminary TEA shows that the use of the CO₂/WGS MFEC reactor reduces the capital cost by > 20 % for the gas cleanup section in large scale IGCC system.

Future Work

- Investigate reactivation of deactivated sorbent due to aggressive regeneration
- Complete long term test to demonstrate durability
- Finalize TEA and submit final report

Acknowledgement

- Funding Provided by US Department of Energy, National Energy Technology Laboratory and Southern Research under Co-operative Agreement # DE-FE0026388
- DOE Project Manager: Isaac “Andy” Aurelio DOE/NETL
- Intramicon: Paul Dimick
- Nexant: Gerry Choi
- Engineers: Brittany Basu and Kevin McCabe, and support staff at Southern Research

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