Combined Sorbent/WGS-Based CO_2 Capture Process with Integrated Heat Management for IGCC Systems (FE0026388)

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Project Overview

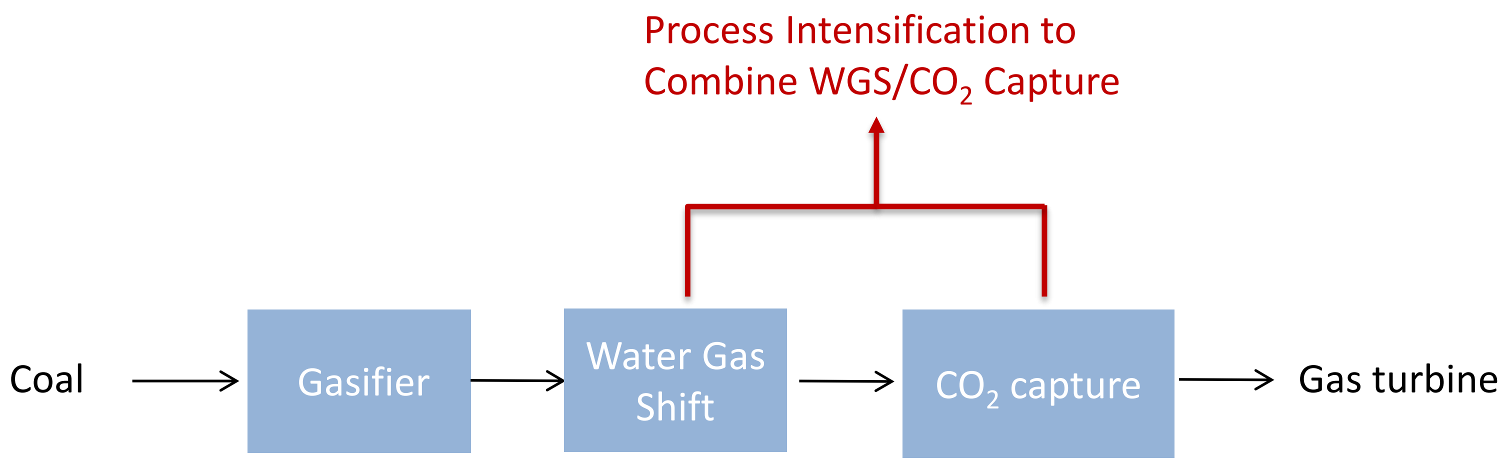
- Southern Research is developing an MgO sorbent-based combined CO_2 capture / water-gas shift (WGS) process for integrated gasification combined cycle (IGCC) power plants.

- 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 CO_2**
- **Potential for reduction in cost of electricity for IGCC plants with CO_2 capture**



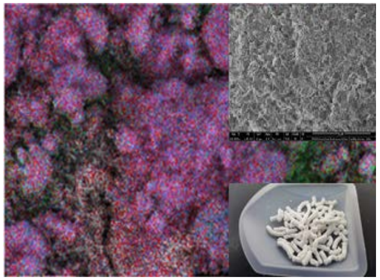
Project Innovations

- Combine a commercial WGS catalyst with a novel magnesium oxide based CO_2 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/CO_2 sorbent reactor enables higher CO_2 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 CO_2 sorbent; Separately test performance of WGS catalyst and CO_2 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

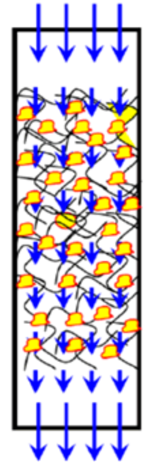
Technical Approach (continued)

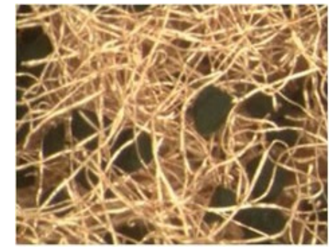


Sorbents

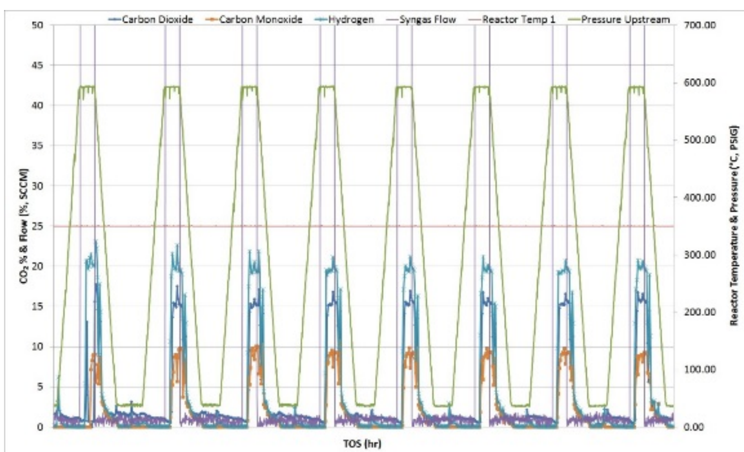
TGA
BET
SEM
EDS

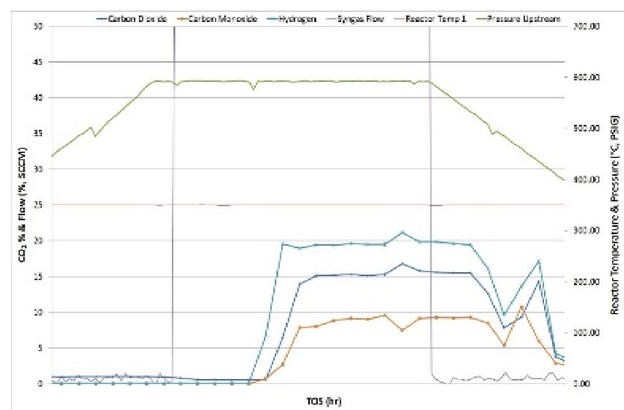
Characterization





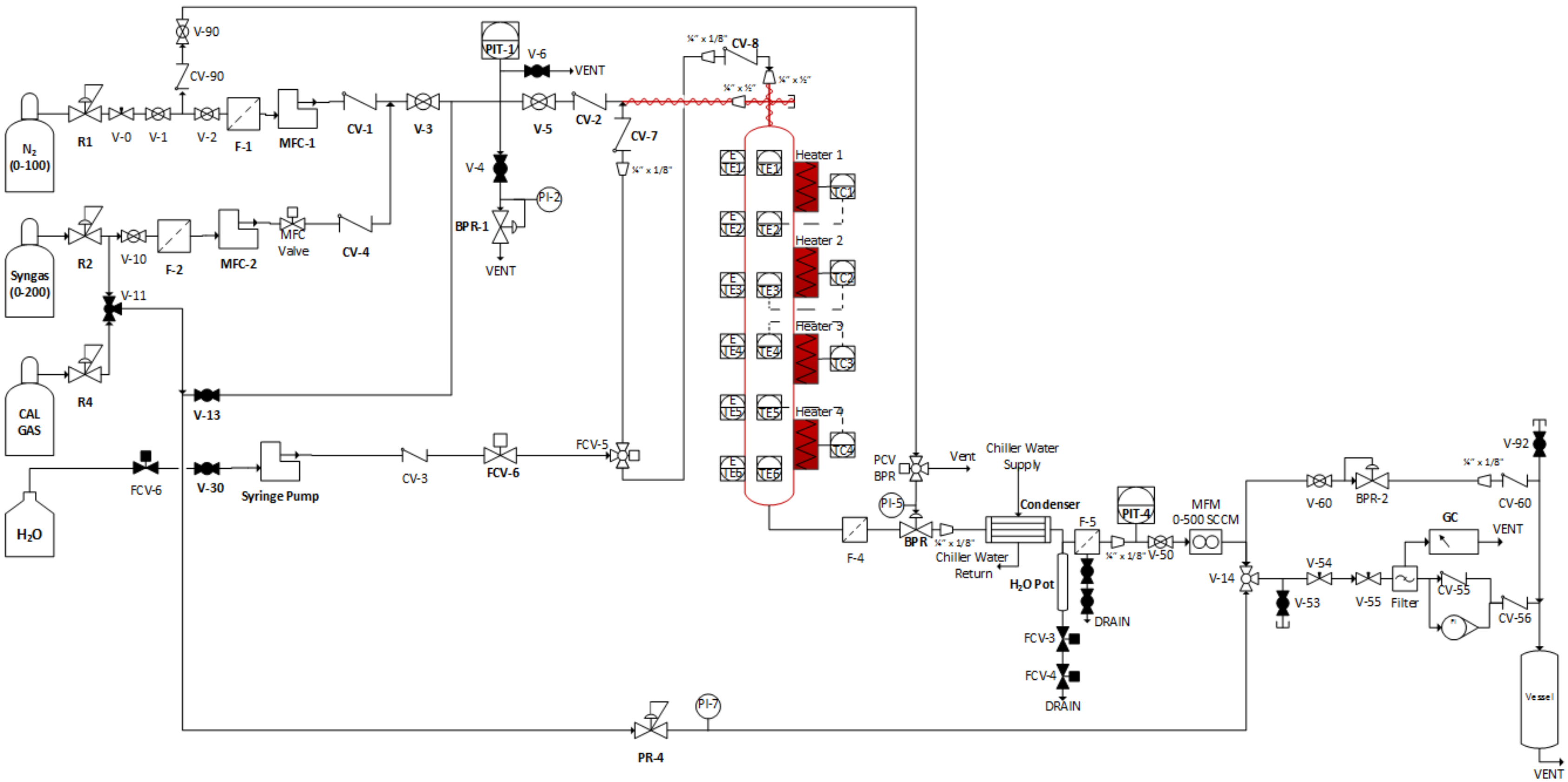
Reactors





Results

Bench-Scale Reactor System

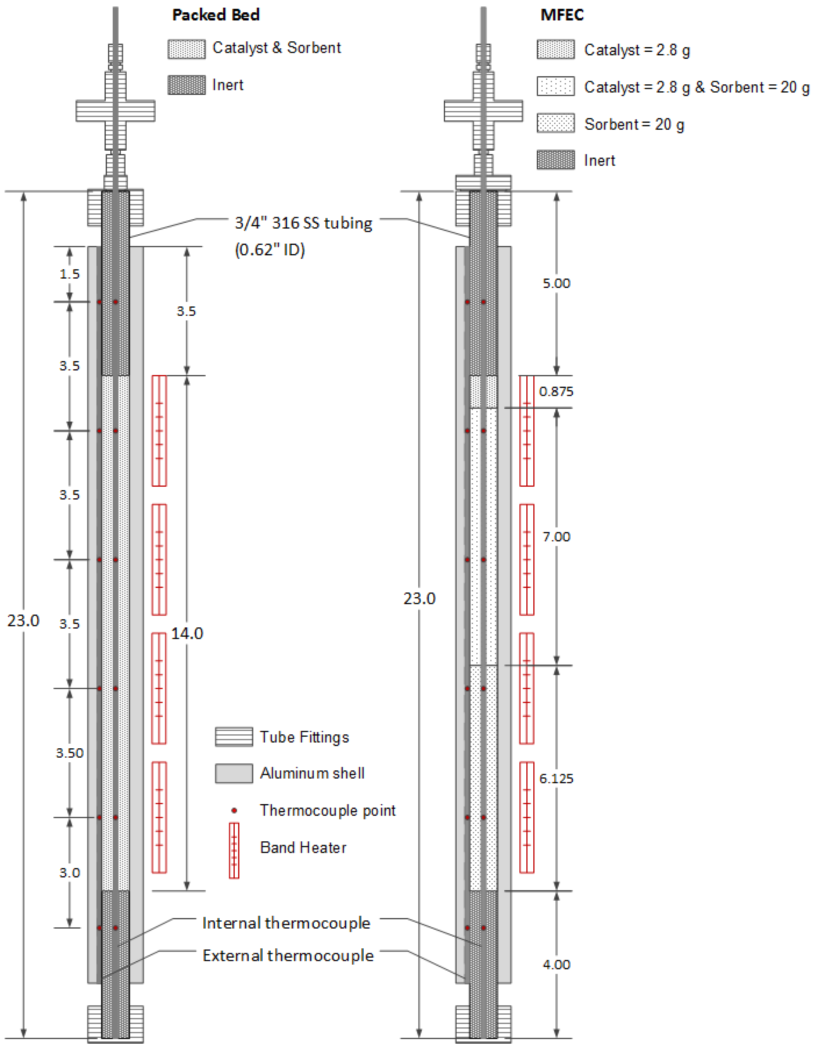


SR

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* ¾ (OD)	14* ¾ (OD)
Sorbent / g	40	15
Catalyst / cc	12	5
Inert Dilute	N/A	SiC
Particle Size / micrometer	50	800

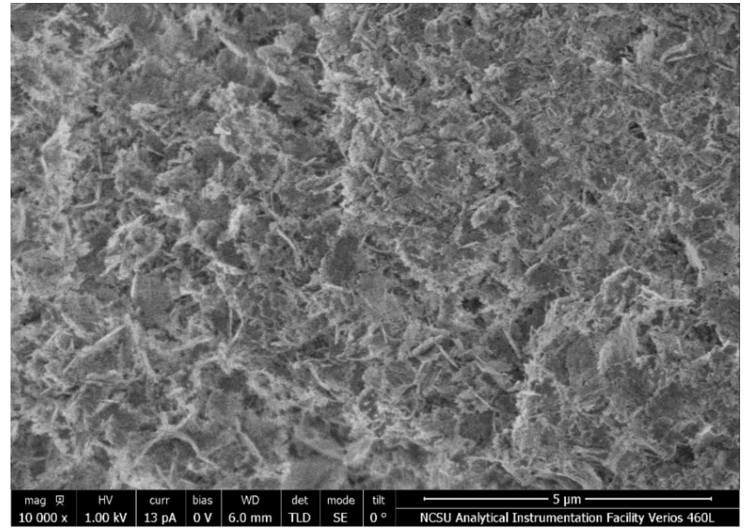
MFEC capable of holding 2.6 times more material in same reactor volume

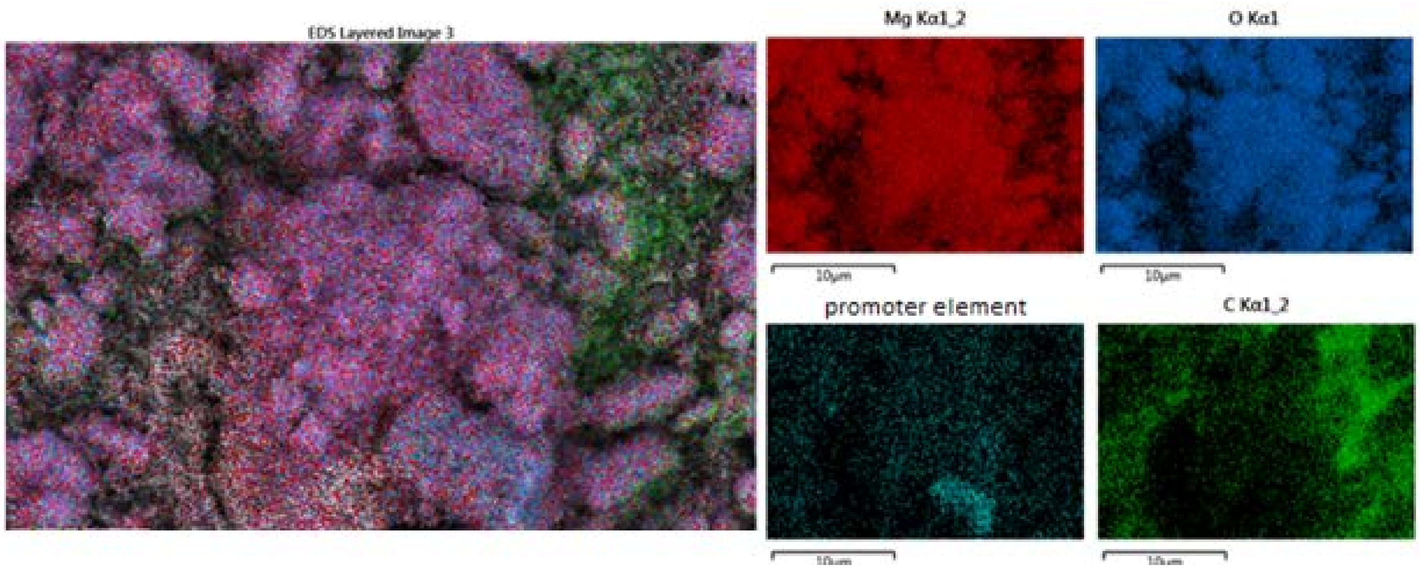
MFEC had <1/2 the temperature variation compared to diluted packed bed

Highlights of Results

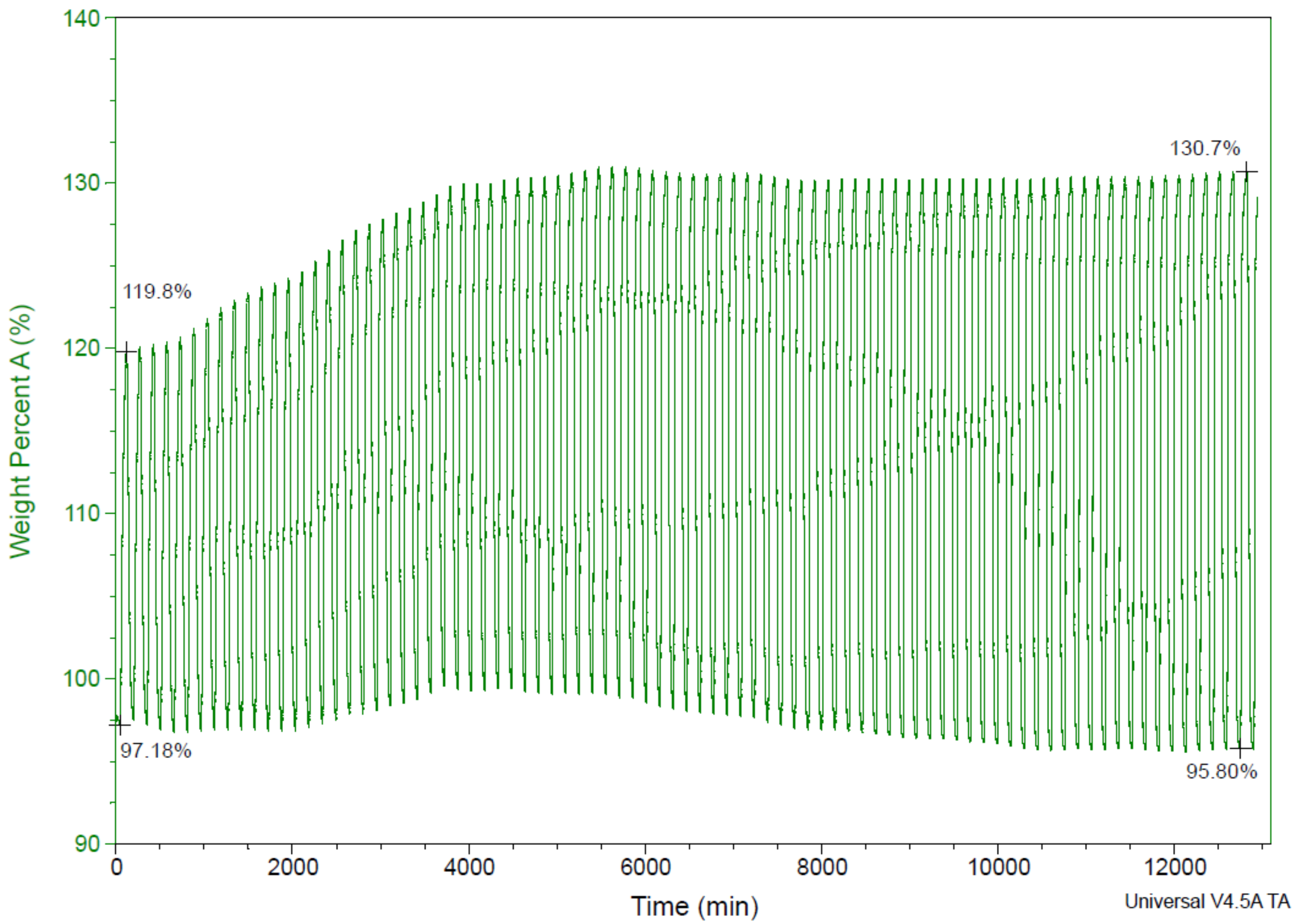
Sorbent Characteristics

SR 1.3 promoted MgO





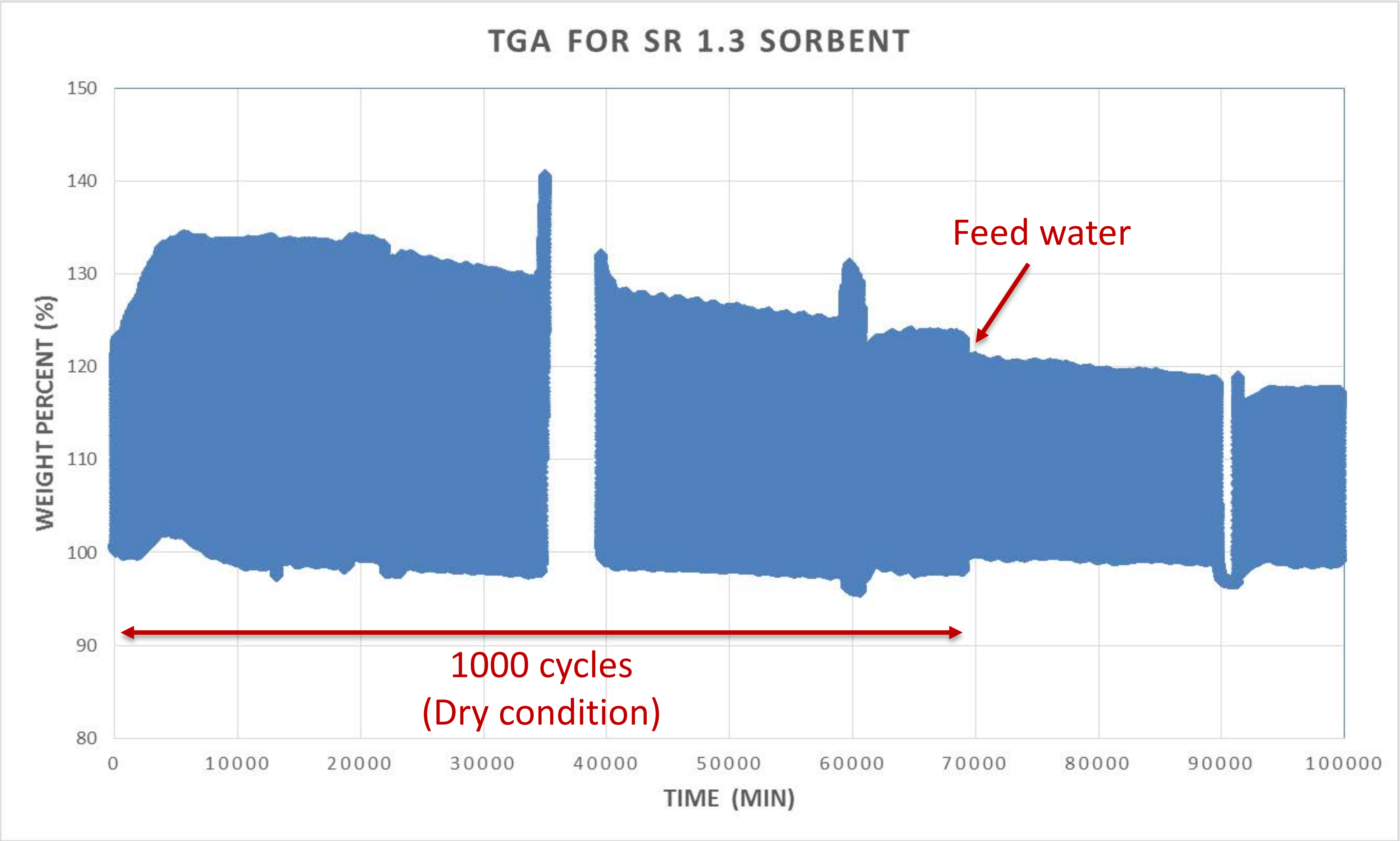
TGA Sorbent Performance
(Mild Regeneration)



36% weight gain
Over 100 cycles

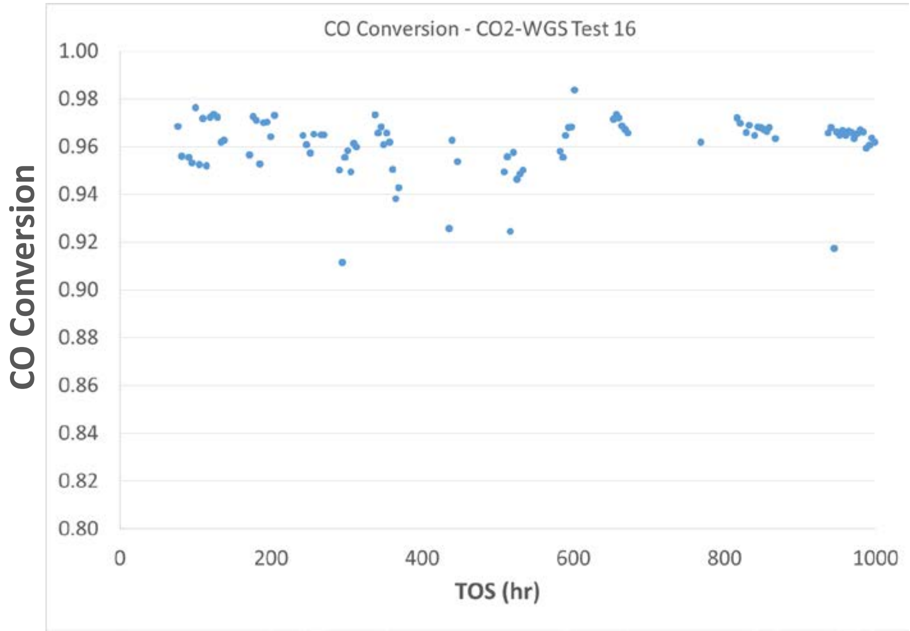
8 mmol/g CO_2
sorbent capacity

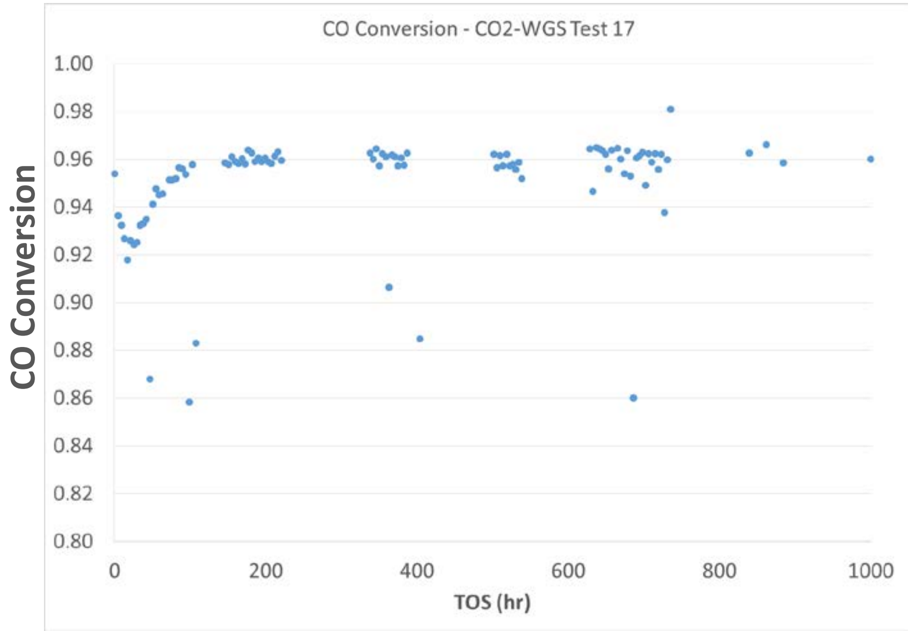
TGA Sorbent Performance
(Aggressive Regeneration)



Combined Reactor WGS Performance

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

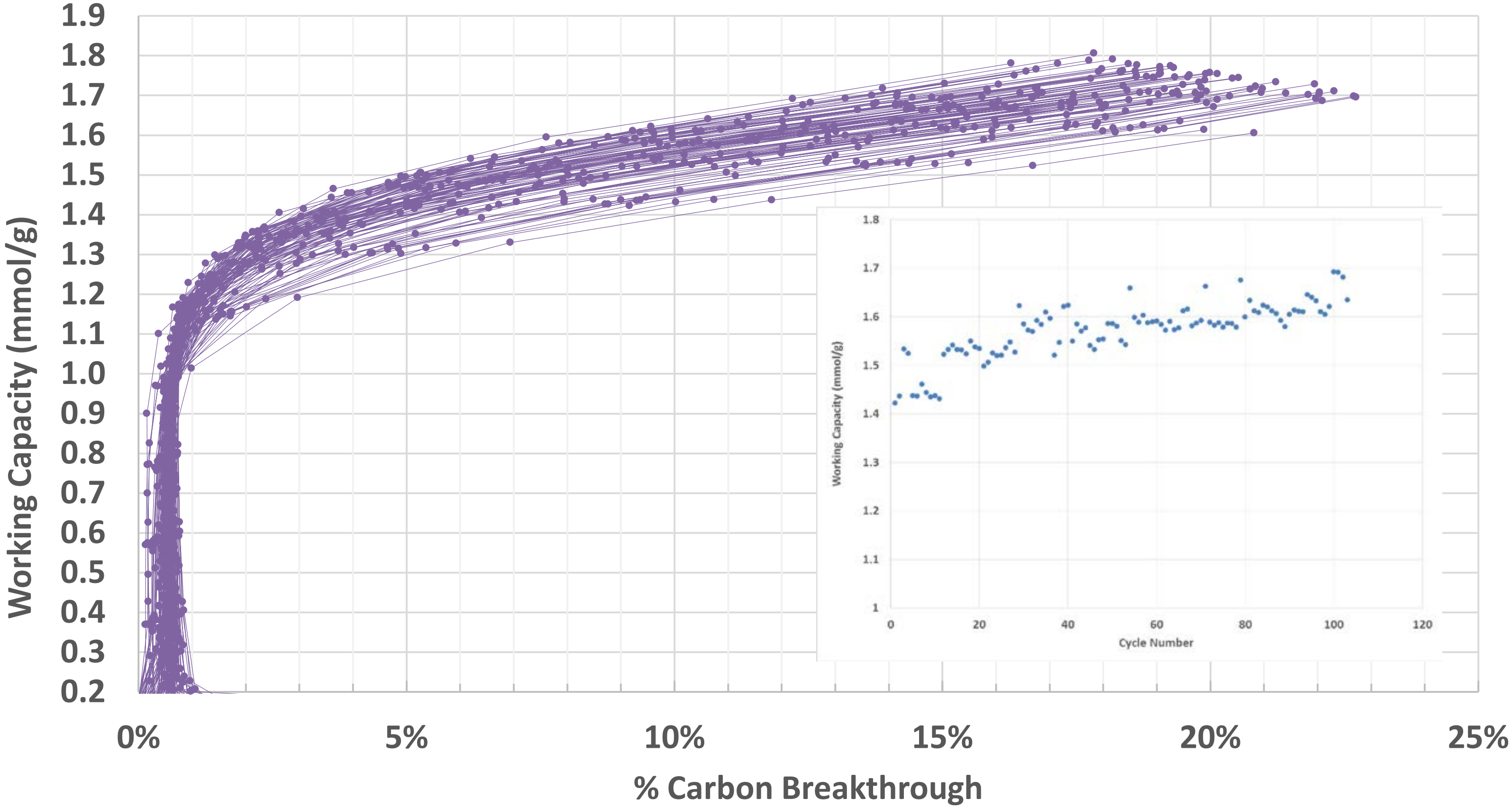




Packed-bed Reactor

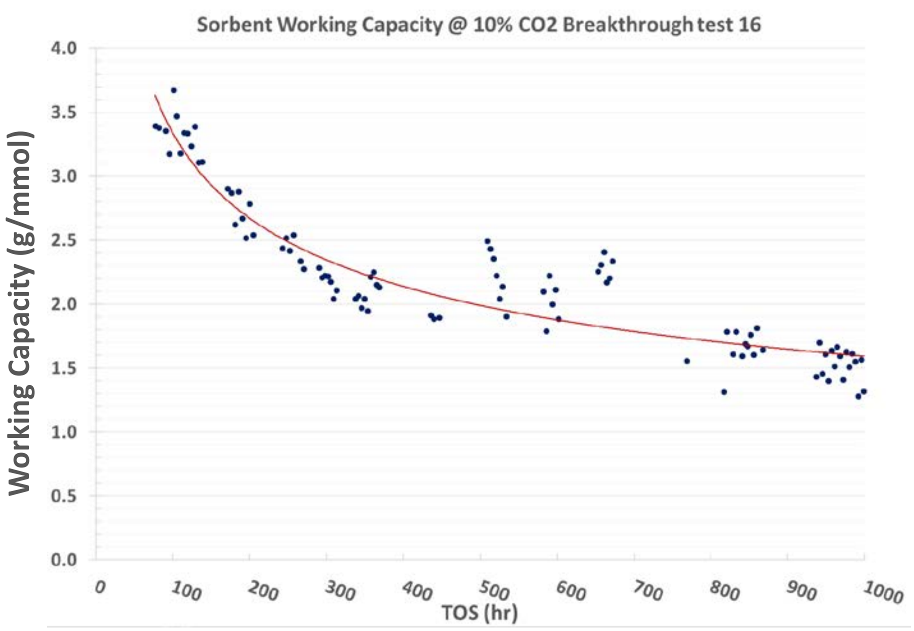
MFEC Reactor

Sorbent Performance (mild regeneration)

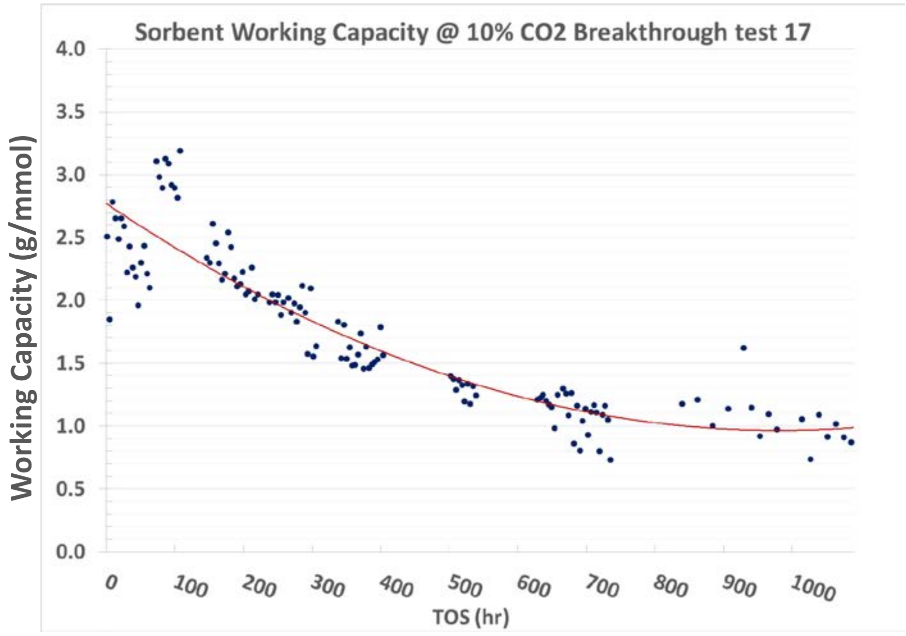


265 cycle test

Sorbent Working Capacity (Aggressive Regeneration)



Packed bed Reactor



MFEC Reactor

Conclusions and Future Work

Conclusions

- A promising CO_2 sorbent with CO2 capacity over 8 mmol/g has been developed.
- A combined process for WGS and CO_2 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 CO_2 working capacity but results in lower working capacity when sorbent stabilizes
- Preliminary TEA shows that the use of the CO_2/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

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- Engineers: Brittany Basu and Kevin McCabe, and support staff at Southern Research

Disclaimer