Pilot Unit Testing at NCCC of Sorbent based CO$_2$ Capture Project # DE-FE0012870

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August 12, 2021
Project Overview

DOE Project DE-FE0012870
Funding - Total Project $6,480,377
  DOE $5,204,509
  Cost share $1,275,860
Partners: ExxonMobil, UCI, & NCCC

- **Budget Period 1: Optimization & Design**
- **Budget Period 2: Construction & Installation**
  - Pilot Unit Construction
  - Sorbent Production Scale-up and Quality Assurance
  - Pilot Unit Installation
- **Budget Period 3: Shakedown & Operation**
Sorbent Carbon Capture Technology

We have developed:

- A low-cost, alkalized alumina adsorbent
- A CO₂ capture process designed specifically for this sorbent
- A unique CO₂ capture process to run adsorption and regeneration at near isothermal conditions

Heat of adsorption ranges from 3 kcal/mole at higher CO₂ concentrations of 10-14%, to 10.3 kcal/mole at CO₂ concentrations of 1-5%.
Simulated Moving Bed Process

- **Multiple Fixed Bed Contactor**
  - Provides counter-flow contact between the solids and gases
- **Beds cycle between adsorption and regeneration functions**
- **Gas flows in parallel through adsorption beds and in series across regeneration beds**

Advantages over moving bed
- Moving bed had expensive conveyors, although the beds would be smaller
- Multiple fixed bed design
  - Basic duct work
  - Low cost construction
  - Simple bed design
  - Eliminates parasitic power needed to move the sorbent
- Lower overall cost than moving beds
Process Overview

- Low grade steam is used.
- The sorbent cost is estimated $3,000/tonne.
- Due to strip air recycle, the CO$_2$% at capture unit inlet is increased, which benefits the thermodynamics.
- Based on bench unit test data, the capture cost is $37/tonne CO$_2$ (2007 dollar) without TS&M.
Schedule and Milestones

• Completed Milestones
  – Process Flow Pattern Optimization
  – System Design and Engineering
  – Pilot Unit Construction
  – Sorbent Production
  – Pilot Unit Installation and Shakedown

• Next Milestones
  – 1.5 Months of Parametric Testing (In Progress)
  – 2 Months of Steady State Testing
  – Update Techno Economics
Pilot Tests Overview

• Goals of NCCC testing
  – Demonstrate alkalized alumina sorbent technology under realistic conditions at the 0.5 MW_e (~10 tpd CO_2) scale on coal flue gas to collect data necessary for scale up to next level plant.
  – Demonstrate sorbent technology on coal fuel gas and diluted flue gas to simulate NG flue gas

• Planned Testing
  – 1.5 month parametric testing and 2 months steady state testing

National Carbon Capture Center located at the E.C. Gaston power plant (Wilsonville, Alabama)
Pilot Unit System (0.5 MW Demonstration)

Two Sorbent Bed Trailers
- Sorbent trailers house 10 sorbent beds (5 in each trailer) and manifold piping
- Each trailer is insulated and heated to provide an isothermal environment

Service Unit/Instrument Trailer
- Pressure, temperature and flow control for process gases
- Each process gas routed to both sorbent bed trailers
- Houses the control system and all electrical components for power allocation
- A full suite of on-board analyzers to evaluate system performance
Pilot Unit Skids

Trailer #1

Service unit

Trailer #2

Instrument unit

Sorbent vessel

40 ft

32 ft

11.5 ft
Current Pilot Tests Status & Plans

• New sorbent was loaded in June 2021.
• Testing started in mid July 2021.
• Next testing will include:
  – Complete parametric testing
  – Test the optimized flow pattern
  – Running with both coal and NG flue gases
  – Run 2 months of steady state testing
Performance

Steam Saver flow pattern (13.6% dry CO$_2$ in flue gas inlet)

CO$_2$% in the clean flue gas
90+% capture

CO$_2$% in the product outlet
99.9% purity

7/25/2021 data
Split Steam Saver Flow Pattern

- Split steam saver is modified from the steam saver flow pattern to make full use of steam.
- Split steam saver improves the capture rate at the same steam consumption.

<table>
<thead>
<tr>
<th>Date</th>
<th>Flow pattern</th>
<th>Capture, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>7/27/2021</td>
<td>Steam saver</td>
<td>87.7%</td>
</tr>
<tr>
<td>7/27/2021</td>
<td>Split steam saver</td>
<td>89.2%</td>
</tr>
</tbody>
</table>
Summary

• TDA’s CO₂ capture system uses an alkalized alumina sorbent and a nearly isothermal process designed specifically for this sorbent.
• New sorbent was loaded in the pilot unit.
• Parametric tests were run on pilot unit at NCCC.
• 90+% capture and high purity CO₂ product (> 99%) was achieved.
• The split steam saver flow pattern improved the performance over the steam saver flow pattern.
Acknowledgement

– DOE: Andy O’Palko and Lynn Brickett
– ExxonMobil
– NCCC team
– UCI team

This material is based upon work supported by the Department of Energy Award Number DE-FE0012870.

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