Project Title:

Low-Cost Sorbent for Capturing CO_2 Emissions Generated by Existing Coal-Fired Power Plants

Technology Area:	**Technology Maturity:**
Post-Combustion Sorbents	Bench Scale, ~50 lbs of CO_2/Day, Simulated Flue Gas

Primary Project Goal:

Designing and developing a low-cost solid sorbent that is capable of cost-effectively and efficiently capturing carbon dioxide (CO_2) from existing coal-fired power plants, as well as an adsorption/regeneration process designed around that material.

Technical Goals:

- Use existing information to select candidates for a low-cost, highly efficient CO_2 sorbent.
- Perform TGA, surface area, and crush strength analyses to characterize the sorbent.
- To determine the effects of sulfur oxides (SO_X), nitrogen oxides (NO_X), and water (H_2O) on the working capacity of the optimum sorbent.
- Construct and demonstrate a novel CO_2 removal system for real flue gas stream.

Technical Content:

A variety of existing materials were selected as sorbent candidates. Each material was characterized by TGA, BET, and crush strength tests. The best sorbents were then selected for further evaluation in a fixed bed to be evaluated under repeated absorption and regeneration cycles and to determine working capacity.

A dry regenerable alkalized alumina material was determined to be the best sorbent available for exhibiting features such as a loading capacity of ~0.7%, little performance reduction in the presence of up to 19% water, and near negligible capacity reduction in the presence of up to 300 parts per million (ppm) SO_X. In addition, alkalized alumina is low cost and easily available.

Figure 1 is a sample excerpt plot of CO_2 concentration over time. This experiment was performed using simulated flue gas that contains 13.6% CO_2, 9% H_2O, and 77.2% nitrogen (N_2). The sorbent was regenerated with steam.

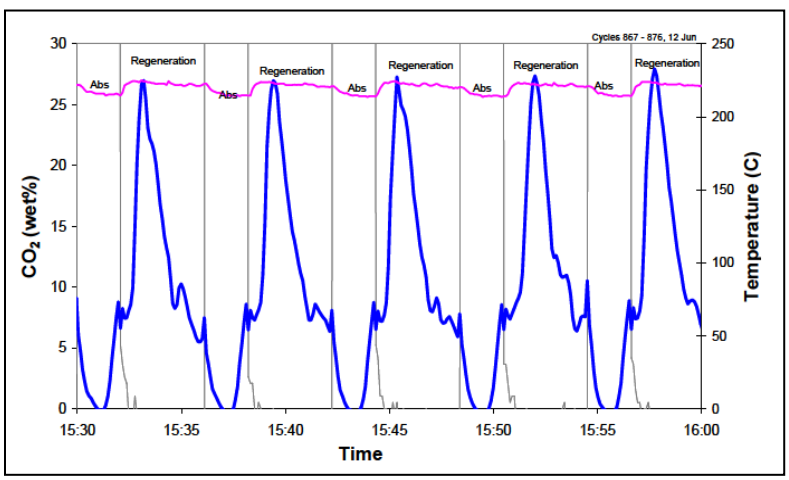

Figure 1: Example of Fixed Bed Screening Test (loading is normalized by the loading under dry conditions)

Figure 2 is an overall schematic of TDA's system, which consists of three primary components: 1) the absorber/regenerator unit; 2) the low-pressure steam generator; and 3) the CO_2 compression and purification unit. The process is designed for the sorbent to pull the dilute CO_2 out of the flue gas at intermediate temperature and near ambient pressure, and then be regenerated with low-pressure superheated steam.

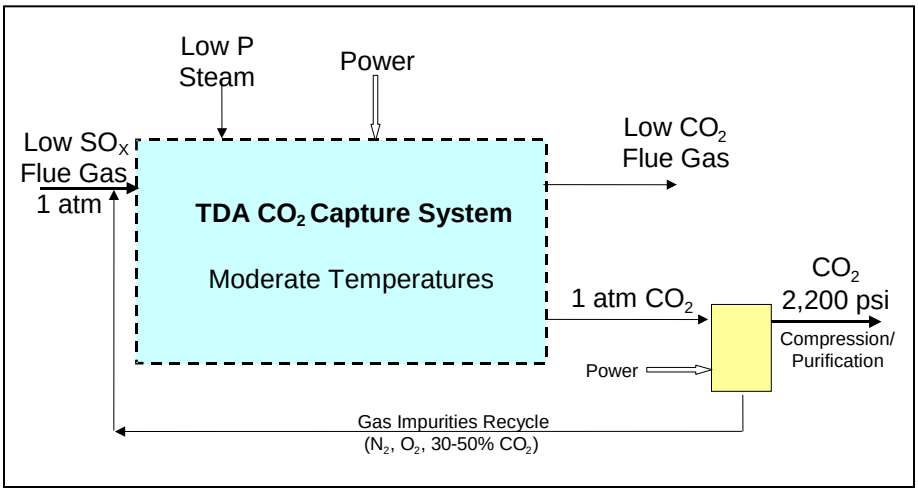

Figure 2: Schematic of TDA's CO_2 Emission Control System

Table 1: Process Parameters

	Parameter	Current R&D Value	Target R&D Value
Sorbent Properties	Type of sorbent	Adsorbent	Adsorbent
	Heat of adsorption (kJ/mole CO_2)	12 to 25	10 to 20
	CO_2 loading/working capacity, wt.%	0.7	1 to 3
	Surface area, m^2/g	100	100 to 150
	Particle density, cm^3/g	0.63	0.6
	Packing density, cm^3/g	1.05	1
	Particle size (mm)	1.6	9.5
	Heat capacity (kJ/K/kg)	0.8	0.8
	Thermal stability, °C	650	>250
	Hydrothermal stability, °C	110 <T <650	110 <T <650
Process Configuration	Attrition rate (fluidized bed), %/year	TBD	TBD
	Cycle time (fixed bed), minutes	5 to 15	5 to 15
	Pressure drop (fixed bed), psia	2 to 5	0.5
Operating Conditions	Adsorption temperature, °C	110 <T <200	110 <T <650
	Adsorption pressure, atm.	1	1.05
	CO_2 capture efficiency, %	90	90
	Regeneration method	steam	steam
	Regeneration temperature, °C	110 <T <200	110 <T <200
	Regeneration pressure, atm.	1	1.05
Heat Integration	Required regeneration steam temperature, °C	TBD	TBD
Miscellaneous	Sorbent make-up rate, $kg/kgCO_2$	TBD	Annual
Product Quality	CO_2 purity, %	TBD	99.99998
	N_2 concentration, %	TBD	1.8e-8
	Other contaminants, %	TBD	1.98e-5
Process Performances	Electricity requirement, $kJ/kgCO_2$	Not available	
	Heat requirement, $kJ/kgCO_2$	Not available	
	Total energy (electricity equivalent), $kJ/kgCO_2$	Not available	

Technology Advantages:

- Low regeneration energy.
- Rapid adsorption/regeneration kinetics due to surface-only adsorption.

R&D Challenges:

- Effectively produce a sorbent from low-cost raw materials with extensive regenerative life of the sorbent.
- Minimizing the parasitic demands from the sorbent system.

Results To Date/Accomplishments:

- Performed TGA, BET, and crush strength analyses on a variety of sorbent materials.
- Determined alkalized alumina to be the optimum sorbent with a loading capacity of 0.7 wt%.
- Performed extended period testing up to 1,800 cycles and found the sorbent maintained its loading capacity at near constant levels throughout.

Next Steps:

- Optimize the sorbent composition and production process.
- Perform sorbent testing and characterization.
- Create a CO_2 capture process design and ASPEN model that includes steam source, CO_2 compression, and heat sources.
- Perform 1,500-hour sorbent cycling test to evaluate the SO_X and NO_X contamination of the sorbent and to complete wear and service assessments of the sorbent.
- Update ASPEN model with experimental data and perform full system and economic evaluation.
- Construct and install a CO_2 capture bench-scale unit and perform shakedown testing.
- Perform CO_2 capture experiments with the sorbent using real coal-derived flue gas.
- Conduct a final system and economic evaluation of the sorbent.

Available Reports/Technical Papers/Presentations:

TDA Research Presentation – March 2009.

Presentation at Pittsburgh Coal Conference, September 22, 2009.

Contract No.:	**NETL Project Manager:**
DE-NT0005497	Andrew O'Palko Andrew.Opalko@NETL.DOE.GOV
Principal Investigator:	**Partners:**
Jeannie E. Elliott TDA Research, Inc. jelliott@tda.com	Louisiana State University (LSU) Western Research Institute (WRI) Babcock & Wilcox (B&W)