Method for Separation of Coal Conversion Products from Sorbent/Oxygen Carriers

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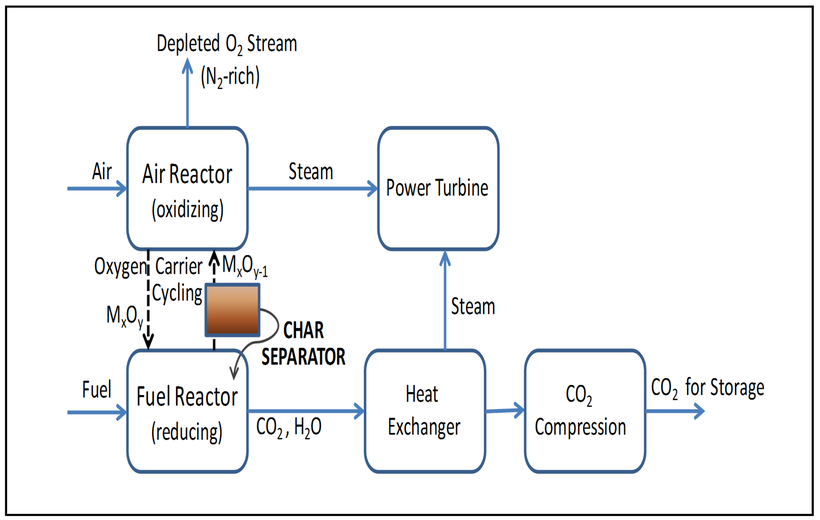
Background - CO_2 Capture

- Chemical-Looping-Combustion (CLC) is an innovative power generation technology that produces a near-pure CO_2 stream (carbon capture) at a lower cost and higher efficiency. Process consists of:
  - Solid oxygen-carrier used to provide oxygen to fuel in fuel reactor
  - Oxygen-depleted solids regenerated separately in air reactor
- Some of the challenges facing CLC development:
  - Unconverted char is entrained to air reactor and forms CO_2
  - This CO_2 is not captured – Carbon Capture Rate (CCR) penalty.
  - Ash resulting from coal conversion can interact with and deactivate OC



Chemical Looping Combustion Process showing Char separator

Project Objectives and Methodology

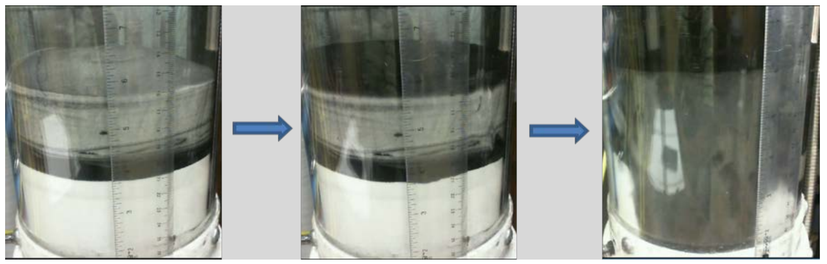
- **Objective:** Develop a char separator to segregate fuel-based char and ash from solid oxygen-carrier before transport to air reactor
- **Methodology**
  - Developed 2 separation technologies based on particle terminal velocity and density.
  - Performed cold flow batch and continuous test to separate OC/char
  - Developed a 100 lb/hr hot flow system to validate separation technologies.

Experimental Setup

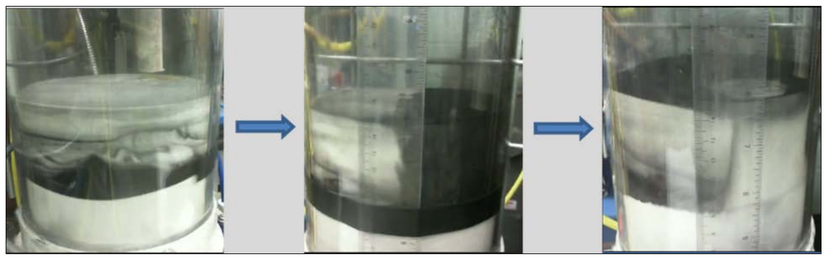
- Elutriation Beds (EB) based on terminal velocity separation
- Large char separator (LCS) used for density-based separation
- Constructed batch systems for proof–of-concept of technology; Used glass beads and carbon (activated carbon) as test medium.
- Continuous flow (50 kg/hr) cold flow units constructed and tested; OC/char from a GE pilot unit and ilmenite/char used.

Results – Phase I

- For LCS performance, "control" was bubbling fluidized bed regime
- Significant back-mixing of the carbon observed during "control"
- LCS showed good separation of carbon with no back-mixing



"Control" test showing carbon mixing behavior (left to right).

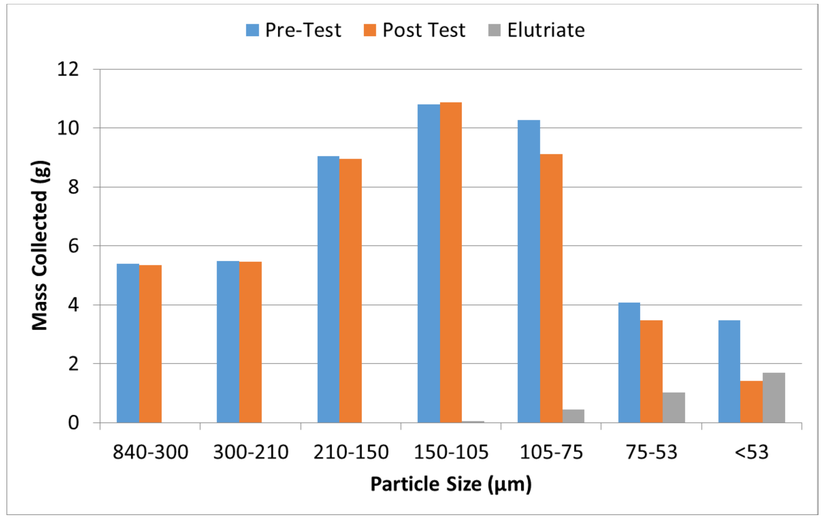


LCS test showing carbon segregating (left to right) with no mixing

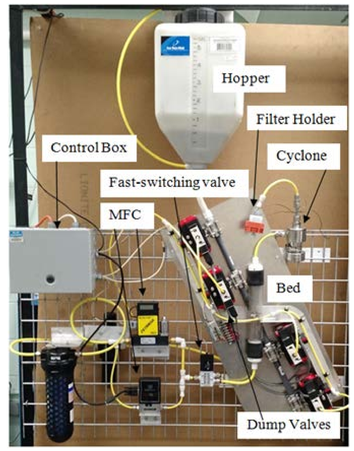
Particle Size (µm)	Carbon Removed
> 420	44%
1200 - 420	34%
420 – 150	35%
150 – 105	6.3%
1< 105	12.9%
> 100 Overall	35%
Overall	**25%**

LCS test with GE OC/char mix. Char segregating to top (left); char removal performance for each size bin (right)

- **30 cm/s** EB bed velocity (minimize OC elutriation).
- For glass/carbon mix, **48% of carbon** removed with **5%** elutriate.
- For GE pilot OC/char, **58% of carbon** removed with **19%** elutriate.



Particle Size Distribution (PSD) of carbon/glass bead mix tested in EB



Size Fraction	Carbon Removed	OC Carried Over
	EB Performance	
> 105 µm	35%	6%
< 105 µm	67%	41%
Total	58%	19%
Combined EB+LCS Performance		
> 105 µm	64%	17%
< 105 µm	80%	49%
Total	**71%**	**29%**

GE OC/Char test unit (left); summary of Phase I results (right)

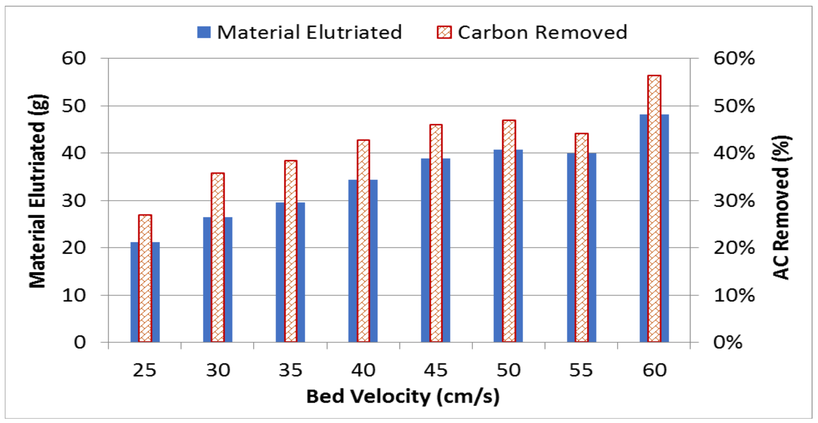
Phase I Discussion

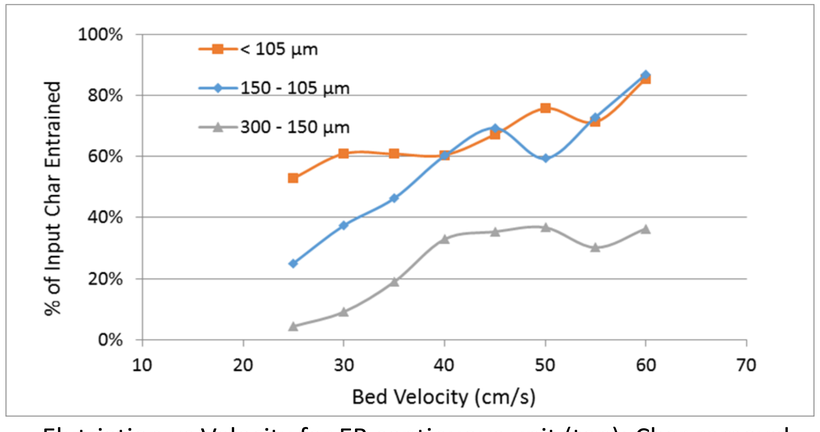
- Technology used for the LCS system facilitated separation of carbon from glass beads while minimizing back-mixing.
- For EB, **>45% carbon removal will result in >15% OC being segregated with carbon**
- **EB alone not suitable for segregating char from OC**
- LCS upstream of EB will help reduce operating velocities in EB and minimize OC entrainment

Results – Phase II

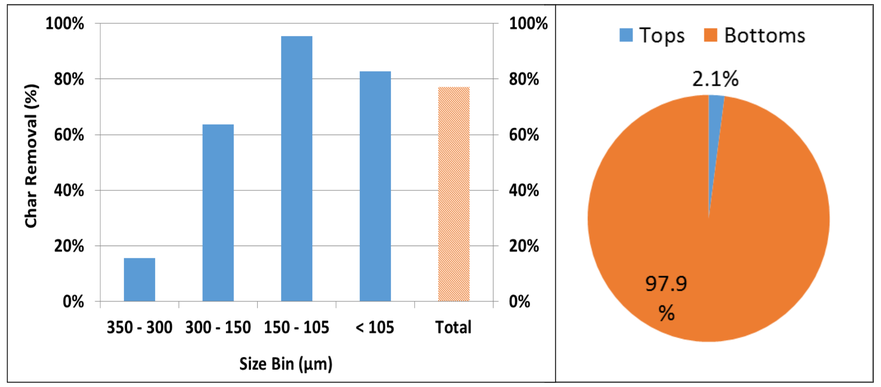
- For LCS system design changed to rectangular unit
- Char produced from a PRB coal using pyrolysis and gasification
- Ilmenite/char PSD overlapped in the 150 to 350 µm range
- Char segregated to top of bed and removed from top exit
- For EB, optimum bed velocity of 50-60 cm/s
- LCS–EB configuration identified as best order for char segregation

Continuous test of LCS showing large char pooling at bed top

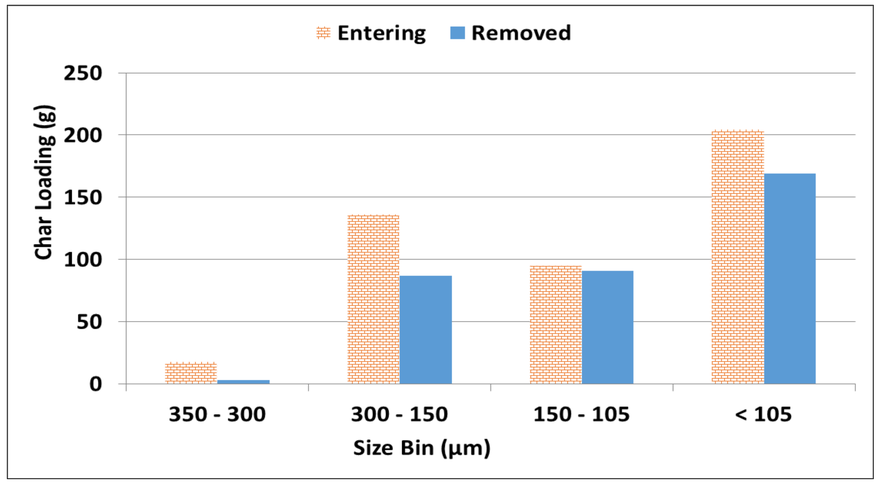




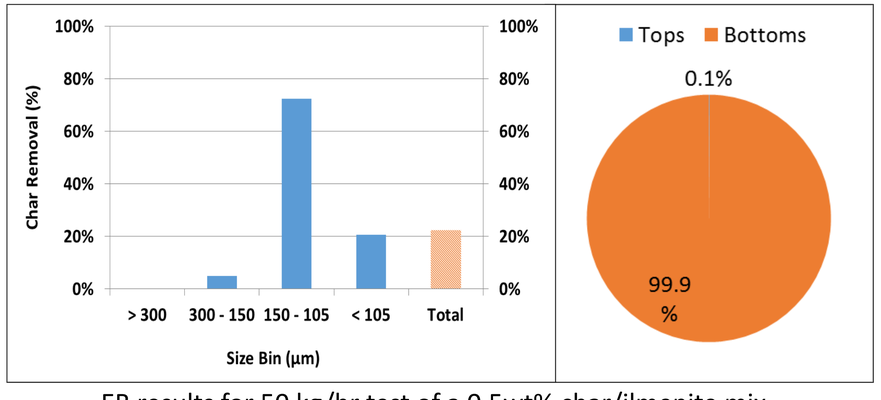
Elutriation vs Velocity for EB continuous unit (top); Char removal efficiency (bottom)



LCS results for 100 lb/hr test of a 0.5wt% char/ilmenite mix



Distribution of Char Entering with and Removed from Ilmenite in LCS

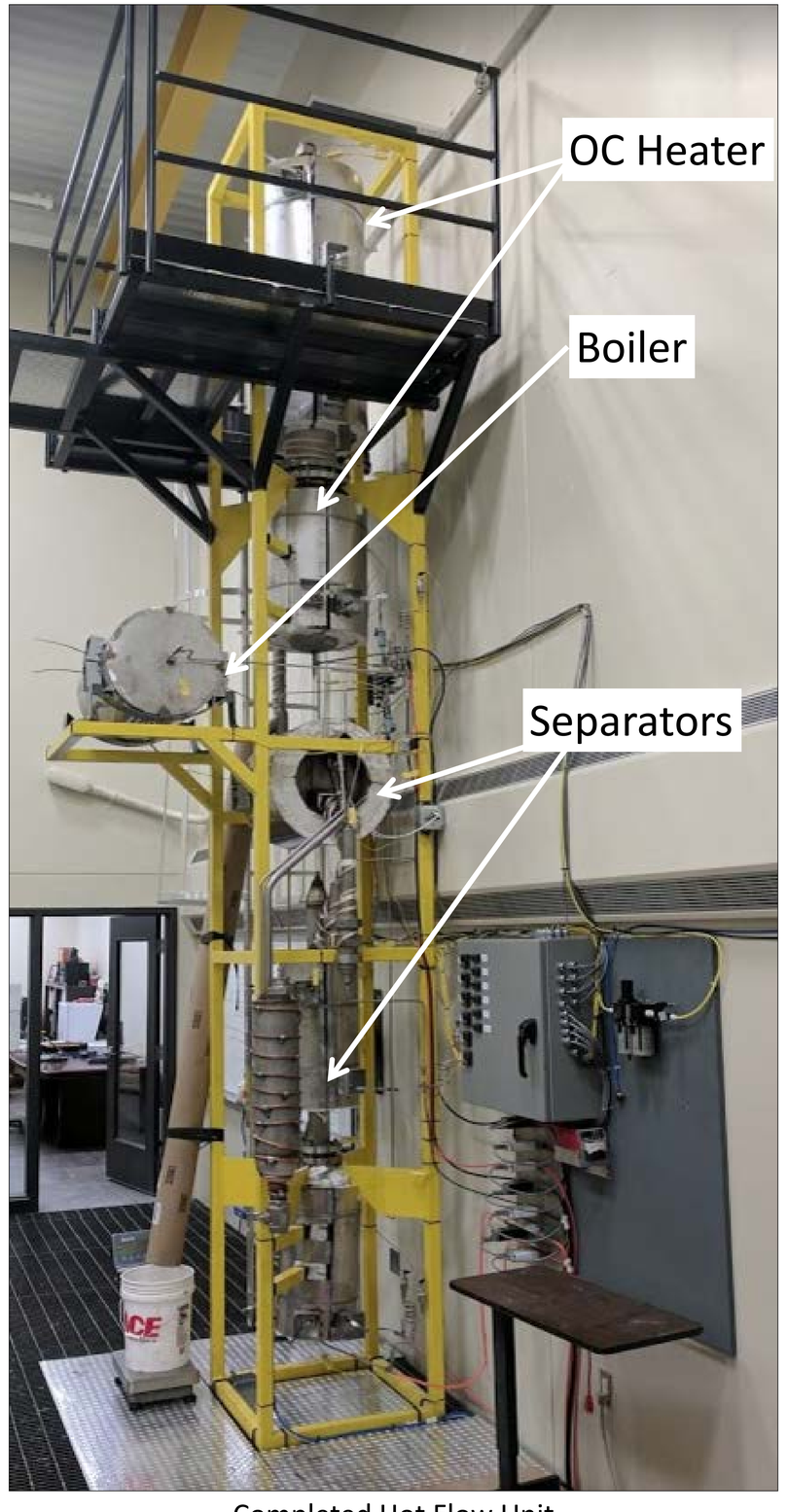


EB results for 50 kg/hr test of a 0.5wt% char/ilmenite mix

Results – Continuous Test

- Significant removal in LCS unit – **0.5% to 13% (26 X enrichment).**
- Char removal by LCS of **77%**
- Char removal by EB of **22%**
- Combined removal for both LCs and EB of **82%**

Hot Flow Unit



Completed Hot Flow Unit

Future Work

- Construction of hot flow 100 lb/hr system (completed)
- Hot flow testing of char/OC mix at CLC operating temperatures (800 – 900°C)
- Construction of cold-Flow 500 kg/hr system for future integration in an actual pilot CLC system

Acknowledgements

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