Improved Refractories for Slagging Gasifiers in IGCC Power Systems

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17th Annual Conference on Fossil Energy Materials
Baltimore, MD
April 22-24, 2003
Gasification

Total Package

Coal
Petroleum
Coke
Refinery Co-products

Oxygen

Gasifier
Particulate Removal

Steam

Syngas

CO₂ & Sulfur Removal

Syngas Conversion

Steam Turbine

Combustion Turbine

Electricity

Back-up/Peaking Fuel

Chemicals

Sulfur

Solids Co-products
Material Challenges Inherent to Slagging Gasifier Technology

- Operating Temperatures of 1250° to 1600°C.
- Thermal Cycling.
- Alternating Reducing and Oxidizing Environment.
- Corrosive Slags of Variable Chemistry.
- Corrosive Gases.
- Pressures ≥ 400 psi.
Gasifier Containment Strategy

- Thermocouple
- Steel Shell
- Refractory Lining
- Flowing Slag
Current “best” refractories last 4 to 18 months, with a replacement cost of up to $1,000,000 and 2-3 weeks downtime.
Current “best” thermocouples do not survive more than a few days of gasifier operation.
Gasifier manufacturers and operators list increased refractory lifetime as one of THE most important needs of the industry.
Project Research Goals:

- Enhance gasifier reliability and economics through the development of
  - Improved refractory materials and repair techniques for longer service life.
  - Longer-life thermocouple assemblies for more reliable temperature control.
Research Approach

- *Post-mortem* evaluation of spent materials to identify failure mechanisms.
- Engineer new materials capable of resisting failure, and test in laboratory.
- Pilot-scale and/or commercial-scale testing.
Refractories: 

*Post-mortem* Evaluation

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Refractories: 
*Post-mortem* Evaluation
Refractories Solution:
Reduce Slag Penetration and Attack
Engineer the matrix composition to encourage reaction with the slag, causing the slag to solidify at the surface of the refractory.
Refractories Solution

ARC’s Improved Refractory

Current Industry Best
Refractories Solution
Optimize Composition for Chemical, Mechanical, & Thermal Stability
Refractories Solution

In collaboration with ANH Refractories, Inc., scale-up production in a commercial setting
Refractories Solution

Expanded testing for chemical, mechanical & thermal stability
Refractories Solution: Rotary Kiln Exposure Test

- > 1650° C
- 5 hour exposure
- Coal Slag from a commercial gasifier
Refractories Solution: Rotary Kiln Exposure Test

ARC/ANH Refractory

Commercial High-Cr$_2$O$_3$ Refractory
Refractories Solution:
Rotary Kiln Exposure Test
Refractories Solution: Next Step

Complete proof-of-concept testing in preparation for placing test panels in commercial gasifiers in early Fall.
Refractories Solution
Next Step: Non-Chrome Alternatives
Thermocouple: \textit{Post-mortem} Evaluation

Two primary failure mechanisms:

- Mechanical failure
- Slag penetration and attack
Thermocouple Solution

Create a more corrosion-resistant thermocouple protection system through the optimization of the ceramic sheath and the development of an improved filler material.
Thermocouple Solution: Coatings

SiO₂ penetration from the slag

“Densified Surface”
Thermocouple Solution: Improved Filler Material

An improved filler material has been developed, along with a dry-pressing method of manufacture that can be readily adapted to a commercial setting.
Thermocouple Solution: Next Step

In collaboration with our industrial partners, manufacture thermocouple assemblies for proof-of-concept testing in working gasifiers
Conclusions

- A modified high-chrome refractory has been developed at the Albany Research Center that shows improved performance in simulated slagging gasifier environments.

- A thermocouple protection assembly is being designed for longer life in a slagging gasifier environment.
Thank You!

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