

**Albany Research Center**

*Solutions that make the Nation's energy systems safe, efficient and secure*

# Improved Refractories for Slagging Gasifiers in IGCC Power Systems

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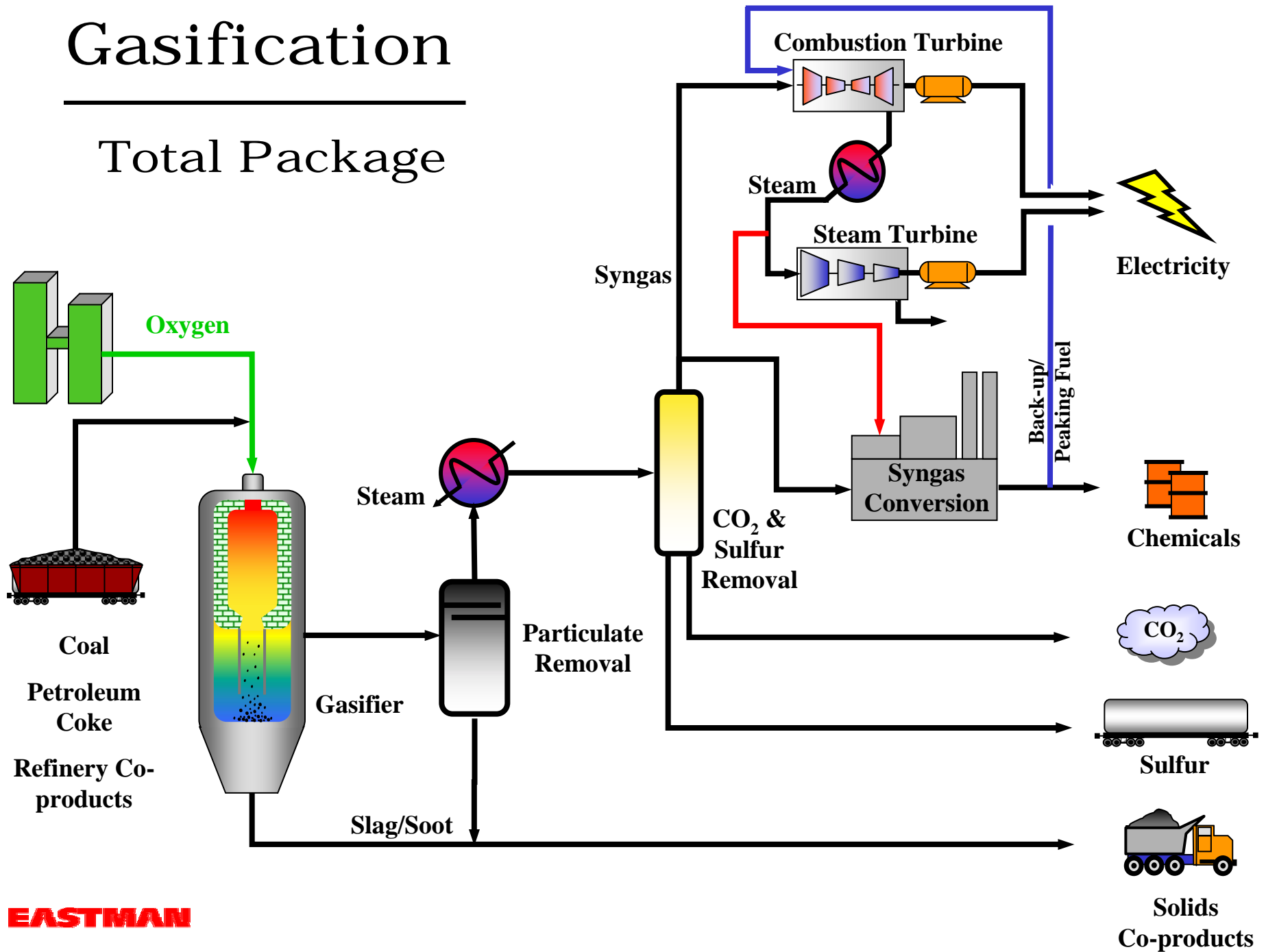
U.S. Department of Energy/Office of Fossil Energy

17<sup>th</sup> Annual Conference on Fossil Energy Materials  
Baltimore, MD  
April 22-24, 2003



# Gasification

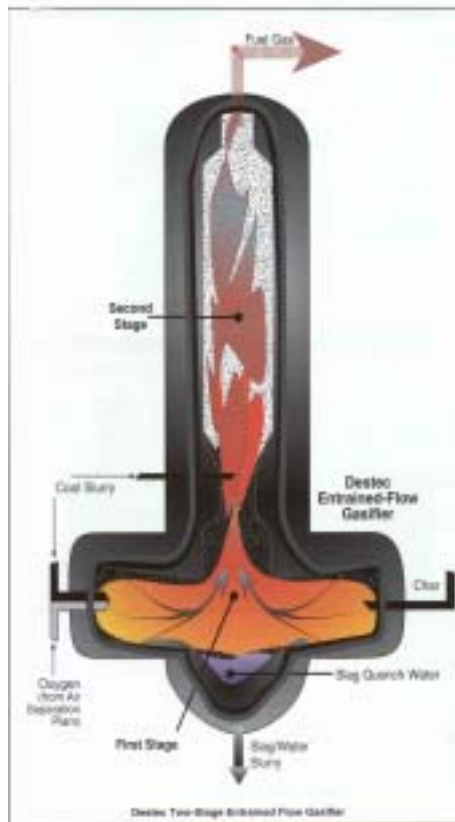
## Total Package





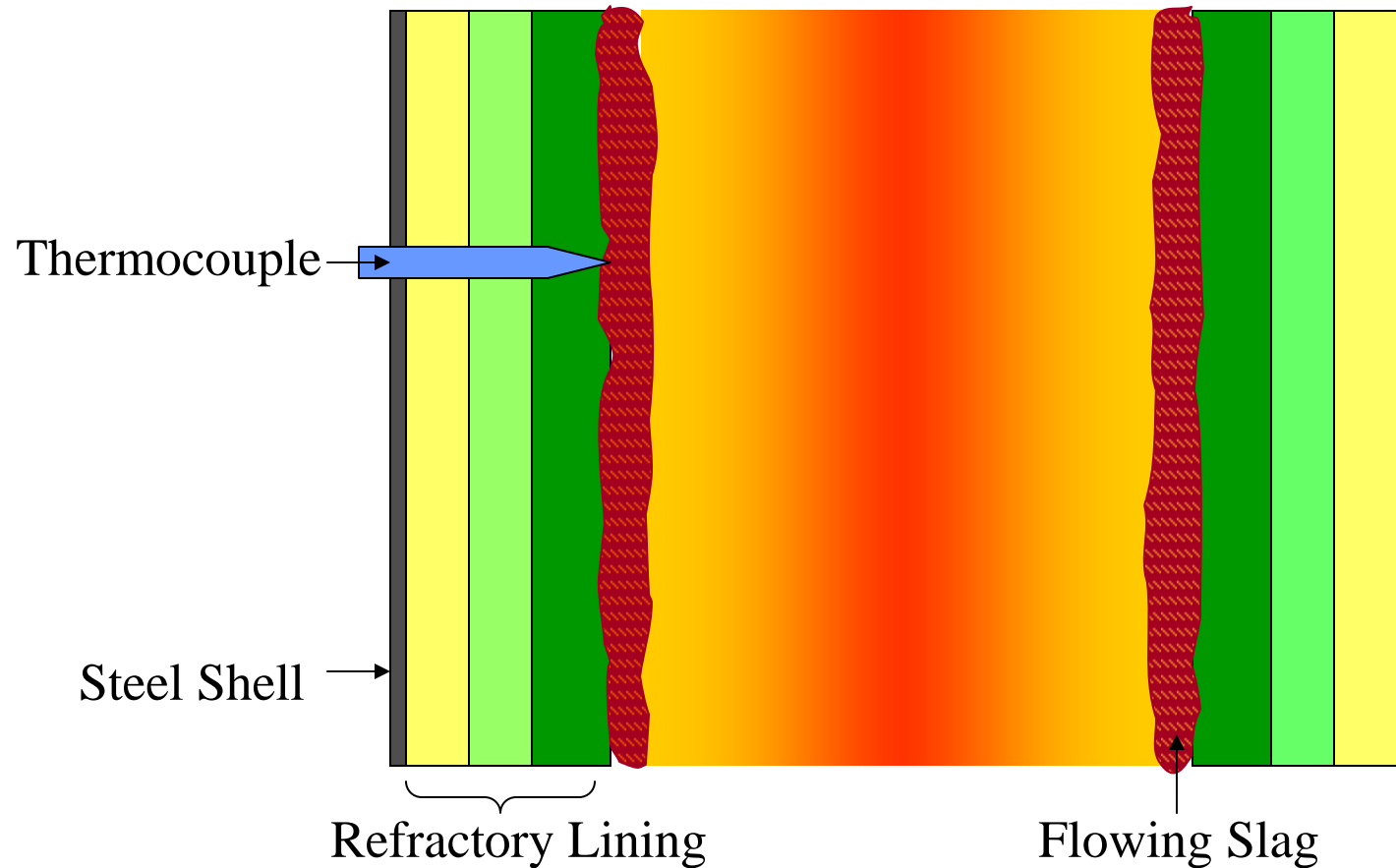
# Material Challenges Inherent to Slagging Gasifier Technology

- Operating Temperatures of 1250° to 1600°C.
- Thermal Cycling.
- Alternating Reducing and Oxidizing Environment.
- Corrosive Slags of Variable Chemistry.
- Corrosive Gases.
- Pressures  $\geq 400$  psi.





# Gasifier Containment Strategy





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.

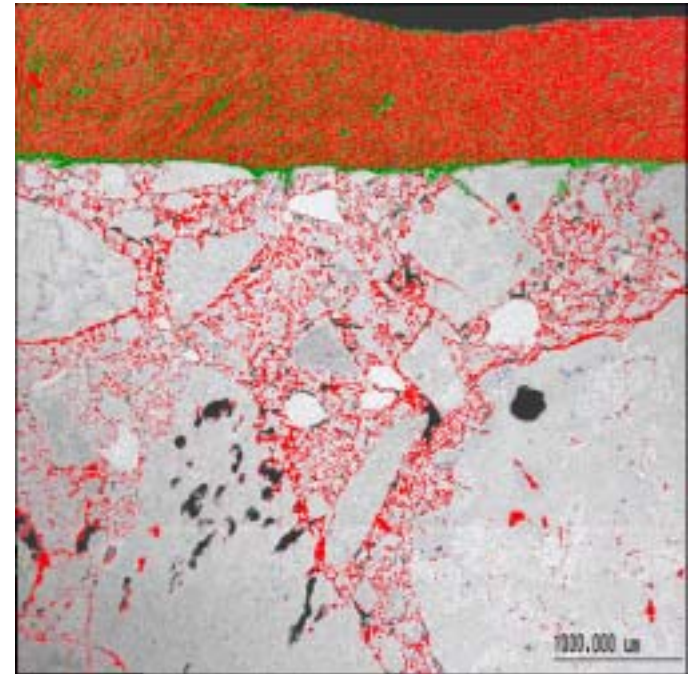
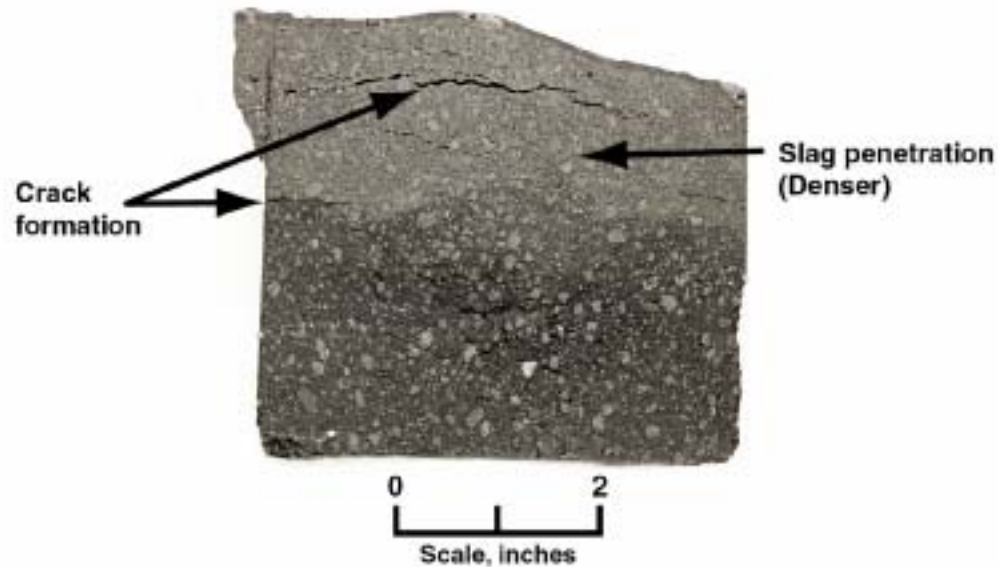


# Refractories: *Post-mortem* Evaluation





# Refractories: *Post-mortem* Evaluation





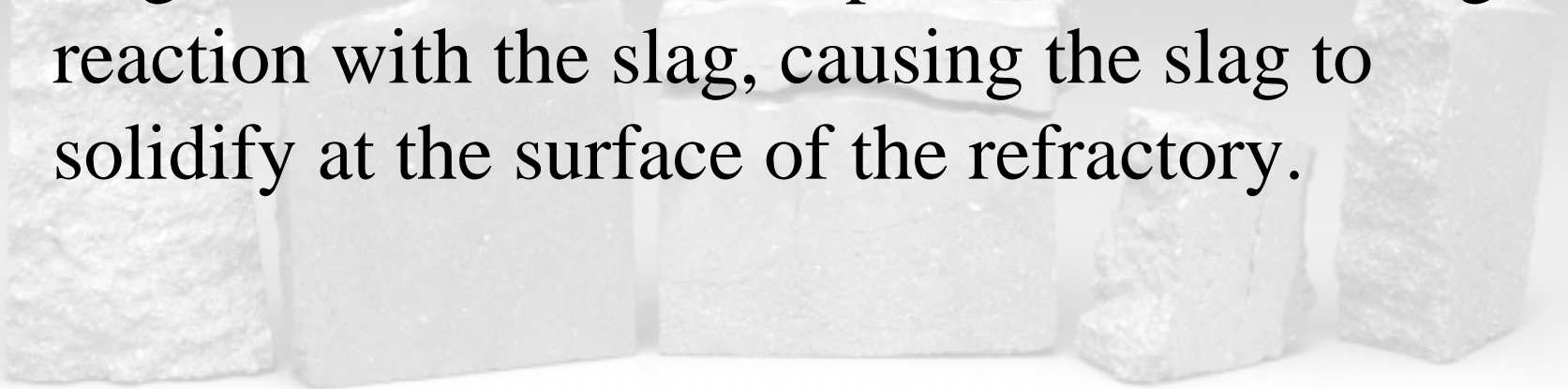
# Refractories Solution: Reduce Slag Penetration and Attack





# Refractories Solution

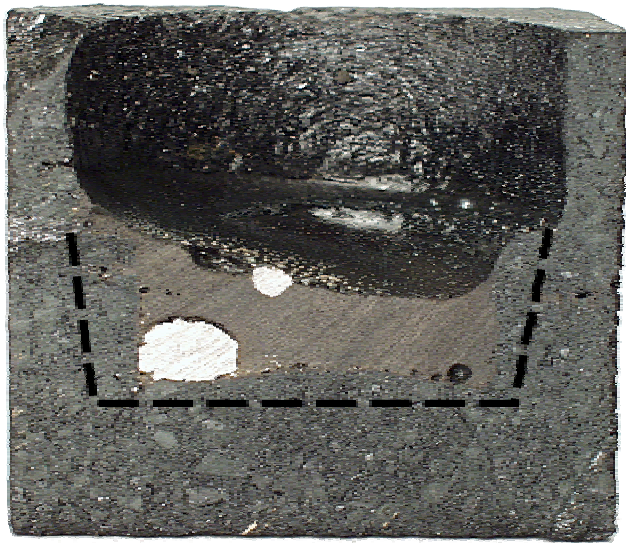
Engineer the matrix composition to encourage reaction with the slag, causing the slag to solidify at the surface of the refractory.







# Refractories Solution



ARC's Improved Refractory

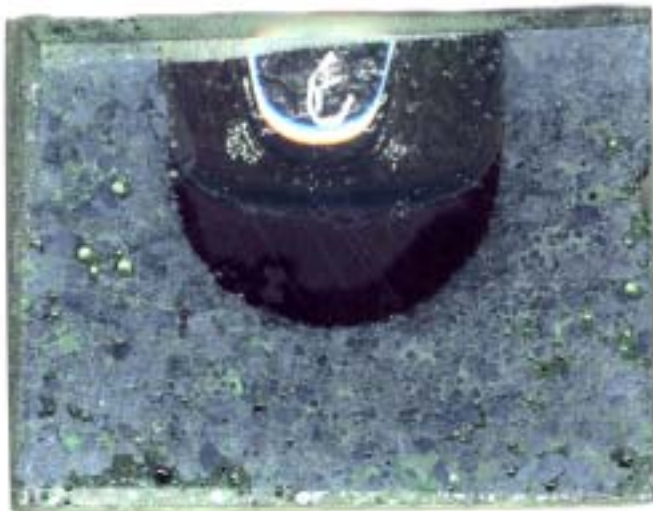


Current Industry Best



# Refractories Solution

## Optimize Composition for Chemical, Mechanical, & Thermal Stability







# Refractories Solution

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





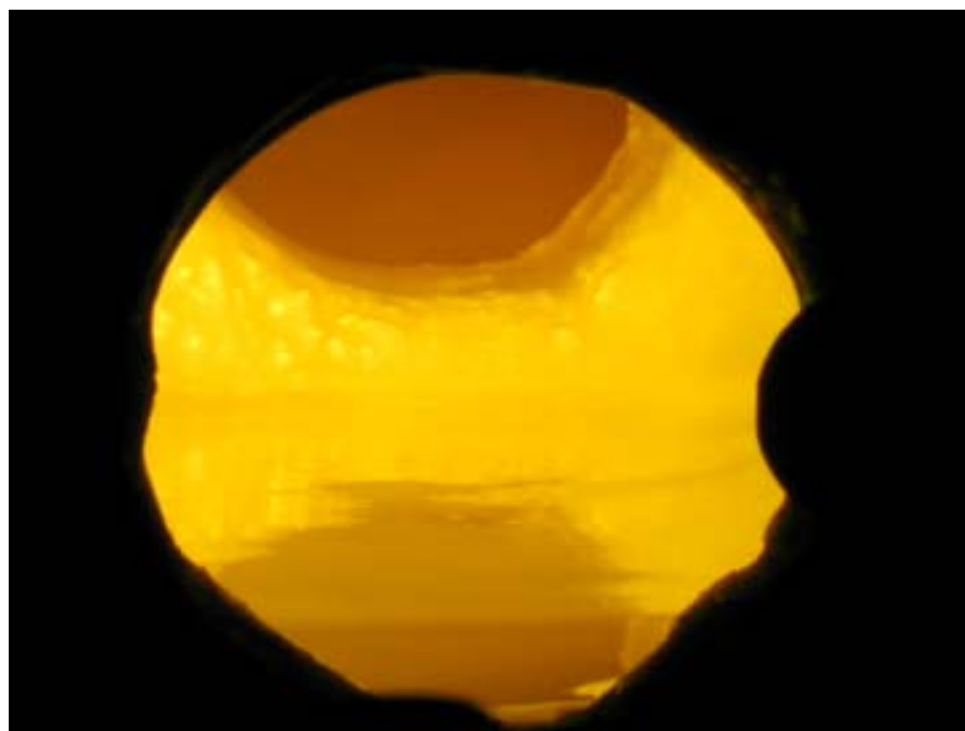
# Refractories Solution

Expanded testing for chemical, mechanical  
& thermal stability





# Refractories Solution: Rotary Kiln Exposure Test



- $> 1650^{\circ} \text{C}$
- 5 hour exposure
- Coal Slag from a commercial gasifier



# Refractories Solution: Rotary Kiln Exposure Test



ARC/ANH Refractory

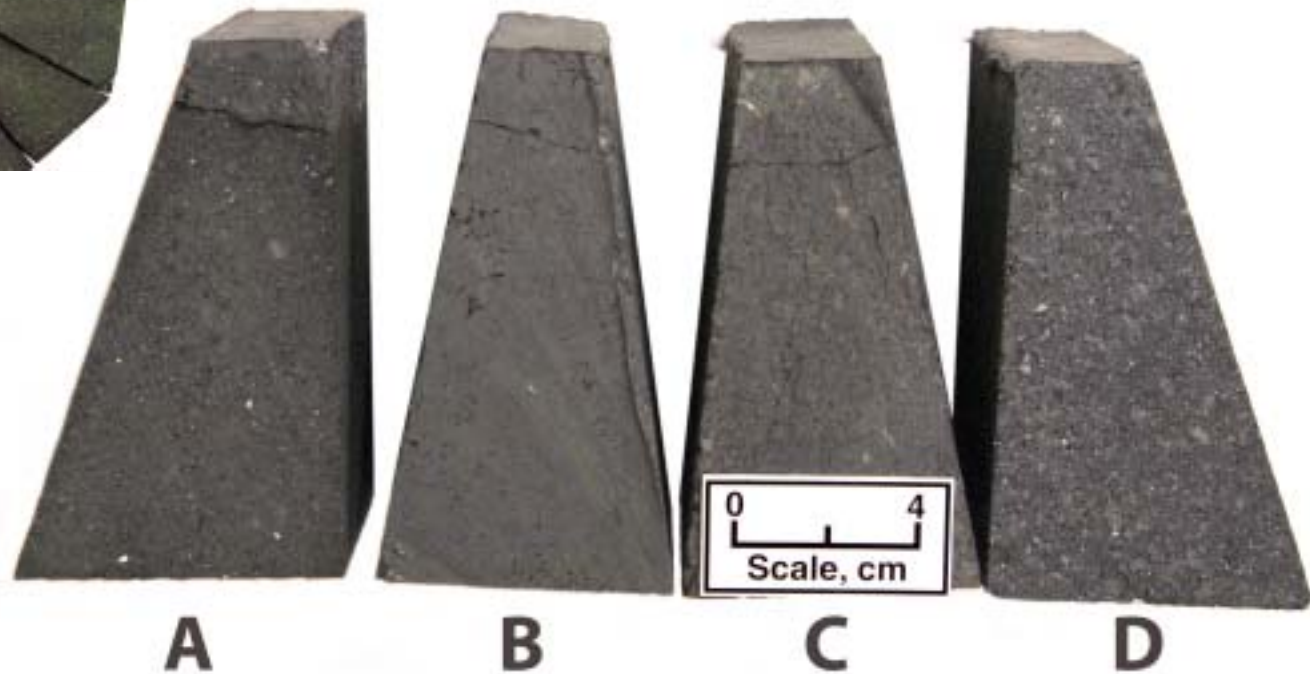
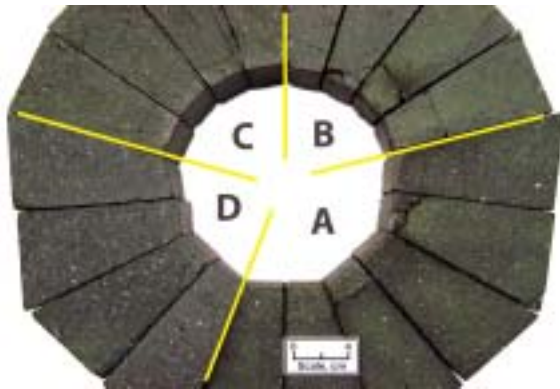


Commercial High-Cr<sub>2</sub>O<sub>3</sub> Refractory





# Refractories Solution: Rotary Kiln Exposure Test





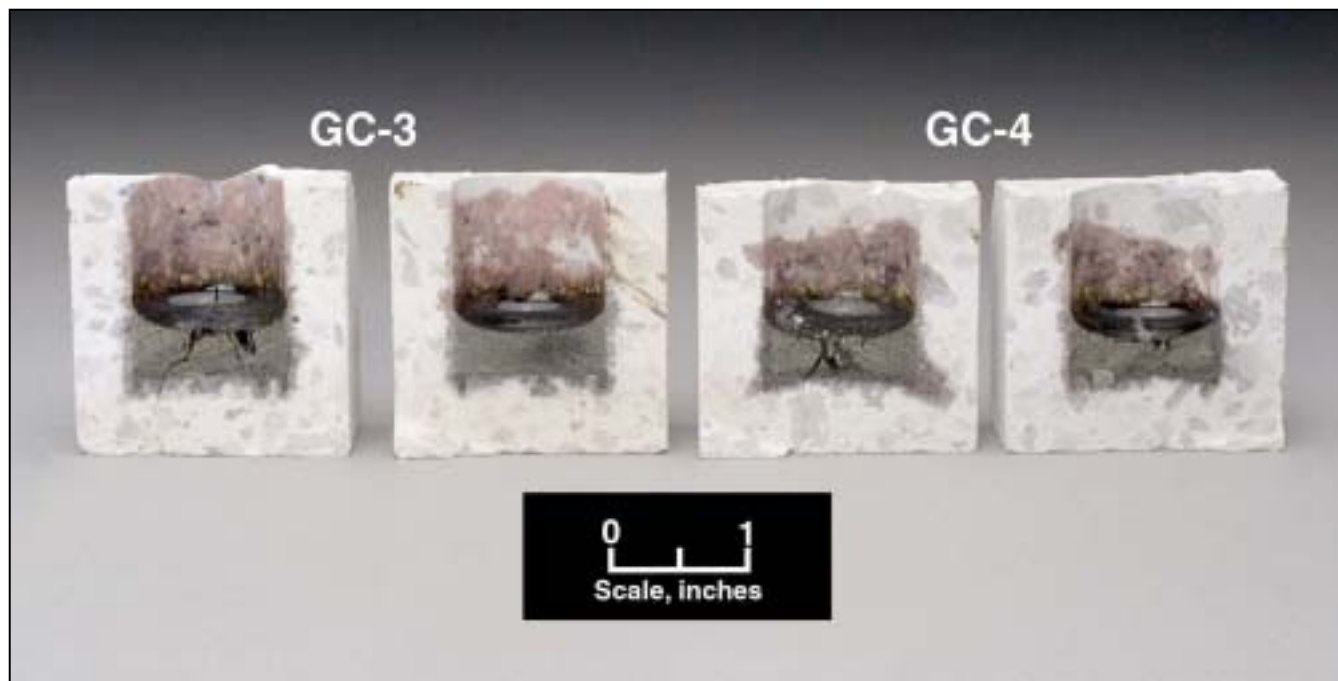
# Refractories Solution: Next Step

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: *Post-mortem* Evaluation

Two primary failure mechanisms:

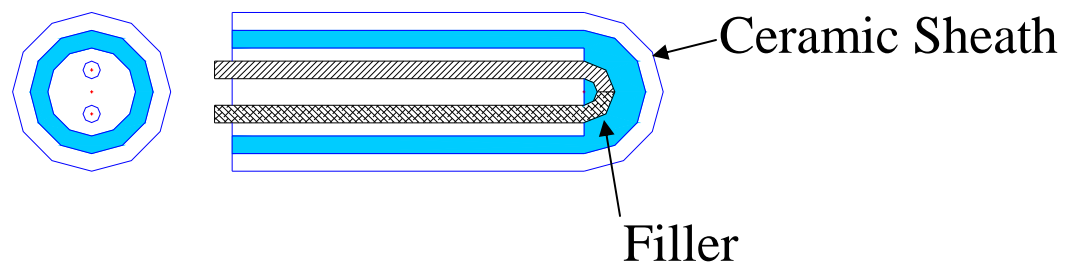
- Mechanical failure
- Slag penetration and attack





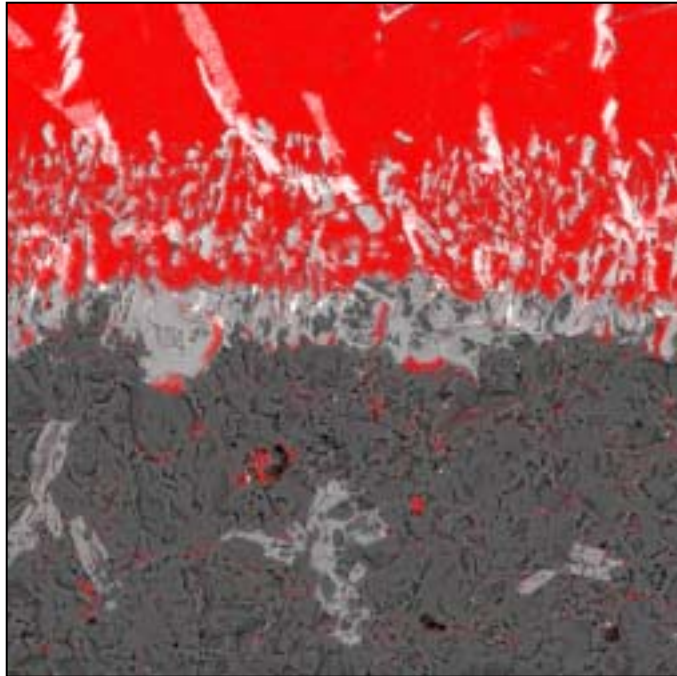
# Thermocouple Solution

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

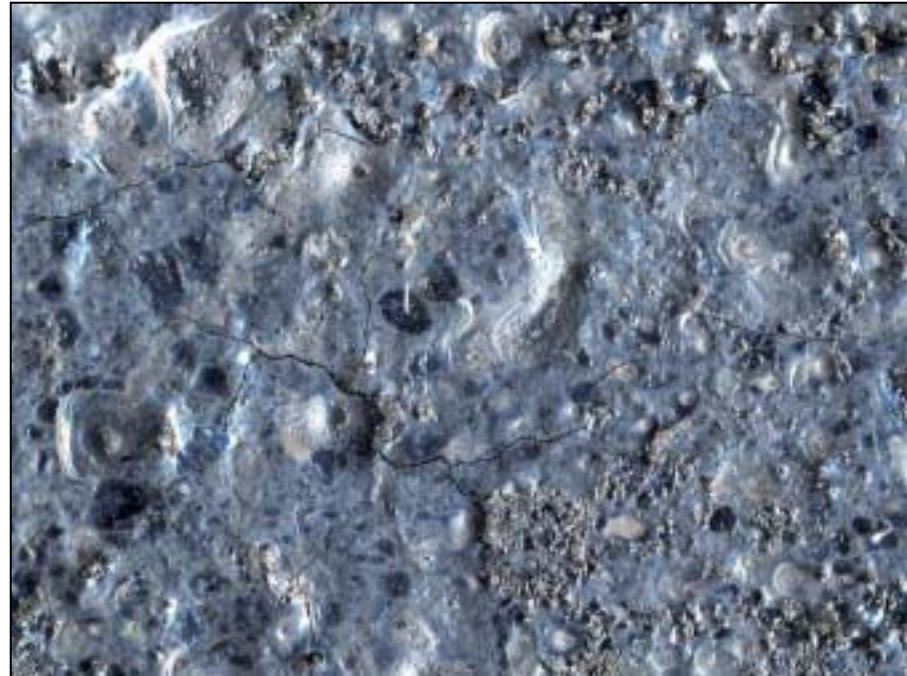




# Thermocouple Solution: Coatings



SiO<sub>2</sub> penetration from the slag



“Densified Surface”



# Thermocouple Solution: Improved Filler Material

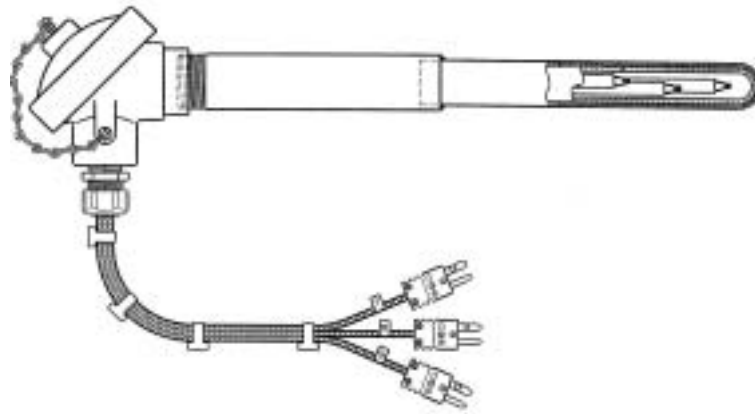


An improved filler material has been developed, along with a dry-pressing method of manufacture that can be readily adapted to a commercial setting.



# 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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