New Developments in Gasifier Refractories

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The Albany Research Center provides materials science and materials engineering solutions that help to make the Nation’s energy systems safe, efficient, and secure.
Why Refractories?

The Reliability, Availability, and Maintainability of the gasifier is directly linked to the performance of the refractory liner in slagging systems.
Material Challenges Inherent to Slagging Gasifier Technology

- Operating Temperatures of 1350° to 1600°C.
- Thermal Cycling.
- Alternating Reducing and Oxidizing Environment.
- Corrosive Slags of Variable Chemistry.
- Corrosive Gases.
- Pressures ≥ 400 psi.
Gasifier Containment Strategy

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 2-4 weeks downtime.
Gasifier manufacturers and operators list increased refractory lifetime as one of the most important needs of the industry.
Strategies to Improve Refractory Performance in Slagging Gasifiers:

• Design a more “slag-resistant” refractory
  – Slag penetration and attack
  – Wear
• Optimize gasifier operating conditions
• Optimize refractory installation
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.
Refractories: 
*Post-mortem* Evaluation
Refactories: 
*Post-mortem* Evaluation
Slag Penetration is Rapid

![Graph showing slag penetration over time with different tests and conditions.]

- Test 1 (1550°C, CO/CO2=2)
- Test 2 (1490°C, CO/CO2=2)
- Test 3 (1550°C, Air)
Typical Refractory Wear in Slagging Gasifier Environments

Exposure Time

Refactory Wear

Dissolution & Wear

Spalling
Refractories Solution:
Reduce Slag Penetration and Attack

- Reduce the volume of interconnected porosity.
- Reduce pore sizes.
- Reduce the wettability of the slag and/or the refractory.
- Induce *in-situ* microstructural changes
  - “Seal” the refractory surface.
  - Solidify the slag within the refractory more quickly.
Refractories Solution

Add phosphates (AlPO₄, CrPO₄, etc.) to the matrix to react with the slag to make the refractory more resistant to slag penetration and resultant material loss.
Refractories Solution

ARC’s Improved Refractory

Current Industry Best
Refractories Solution:
Optimizing Composition
Benefits of phosphate additions:

- Promote a denser refractory body.
- Enhance the bond strength between aggregates.
- Increase the viscosity of the penetrated slag.
- Increase the melting point of the penetrated slag.
- Reduce the wettability of the refractory.
- Increase the corrosion resistance.
- Increase the thermal shock resistance.
Refractories Solution: Next Step

Scale-up using commercial processing techniques to allow for expanded testing.
Refractories Solution: Next Step

Place test panels of ARC’s refractory brick in working gasifiers to verify improved performance.
Summary

A new refractory material has been developed that demonstrates improved stability in simulated gasifier environments.
Improved Refractories mean:

- Reduced Gasifier Down Times.
- Reduced Operating Costs.
- Increased Reliability and Availability.