Advanced Refractory Materials for Improved Energy Efficiency

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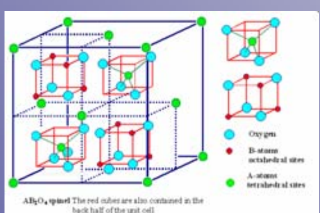
Industrial Partners

Aleris Aluminum
Eastman Chemical
Fireline TCON, Inc.
PPG Industries
Weyerhaeuser, Inc.

Objective

The goal of this work is to develop new refractory materials such as unshaped (castable, gunnable, shotcrete, etc.) spinel type compositions or nano-scale interpenetrating phase composite (IPC) materials that can withstand higher temperatures (100–200°C greater than current materials), can last longer (2 times the life of current materials), and can be more easily installed (new application techniques) or repaired (on-line monitoring and repair) thereby improving the thermal efficiency of process vessels by at least 5%. Such approaches as new aggregate materials, bond systems, protective coatings, and formation techniques will be utilized along with alternative processing techniques and starting materials. Finally, developed materials will be evaluated in industrial applications such as commercial aluminum furnaces, gasifiers (black liquor and coal), glass tanks, and lime kilns.

Unshaped Spinel Type Materials

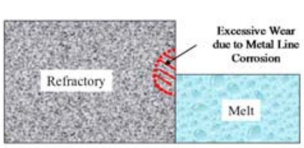


Materials based on the magnesium-aluminum spinel crystal structure which has been found to show high temperature stability, corrosion resistance and low erosion/wear in previous industrial applications.

Other solid solutions forming spinel structures will be considered along with alternative installation methods such as shotcreting.

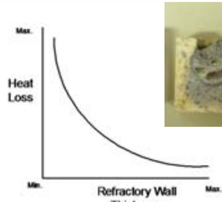
Refractory Attack Mechanisms and Consequences

Mechanism Of Attack	Schematic Of Attack	Effects On Process
General Corrosion		• Impurity pick-up • Reduced efficiency • Reduced surface quality
Preferential Corrosion (Grain Boundary) (Binder Phase)		• Impurity pick-up • Reduced efficiency • Reduced surface quality
Dross Formation		• Reduced efficiency • Reduced product quality
Wear		• Impurity pick-up • Reduced efficiency • Reduced surface quality
Erosion or melt line attack		• Impurity pick-up • Reduced efficiency • Reduced surface quality
Liquid Metal Penetration		• Impurity pick-up • Reduced efficiency • Reduced product quality



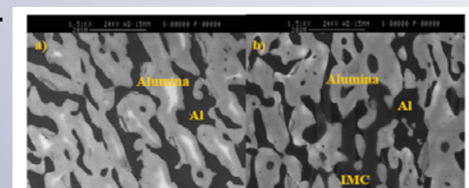
Associated Energy Losses and Environmental Impact

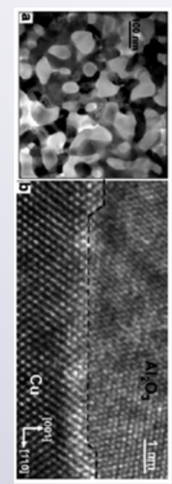
1. Frequent process shutdowns to change hardware or lining material resulting in cooling and reheating of vessel wasting heat and fuel or electricity.
2. Need to produce new lining materials consuming energy and resources.
3. Poor product quality leads to need to remake product or manufacturing of new product consuming additional energy and raw materials.
4. Due to contamination of melt through impurity pick-up purification (filtering) may need to be performed to remove impurities or additional melting may be required consuming energy and fuels.
5. Worn refractories will cause more required energy to run process.
6. Heat losses will increase as lining deteriorates or forms a less insulating phase resulting in loss of energy and greater consumption of fuel or electricity.



Interpenetrating Phase Composite Materials (IPC's)

Nano-scale IPC's with improved mechanical, electrical, and thermal properties have previously been demonstrated at the lab scale (both in literature and at ORNL), but have been limited to thin films.





Although IPC materials with unique properties have been produced in the lab, components of useable size for actual application have not been possible with current processes due to difficulties infiltrating preforms (low wetting) and closing pores within the preform. The technical and economic feasibility of producing nano-scale IPC components of a useable size for testing/implementation in real applications is being investigated through traditional and alternative processing routes.

Energy Impacts

A 5% improvement in energy efficiency would result in savings of 3.7 TBtu/yr (7.2 billion ft^3 natural gas) through implementation in targeted industries.
Energy savings realized through
- **reduction of refractory wear (corrosion and mechanical) leading to heat retained in process and reduced shut-downs for maintenance.**
- **reduced furnace cycling**
- **hot inspection and repair techniques**

Additional benefits of reduced process down time and higher throughputs due to increased process temperatures.

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