



Maximizing Reactor Performance: The Benefits and Challenges of Zirconia Refractories in Carbon Black Production

*Carbon Black World 2025
Fort Worth, TX*

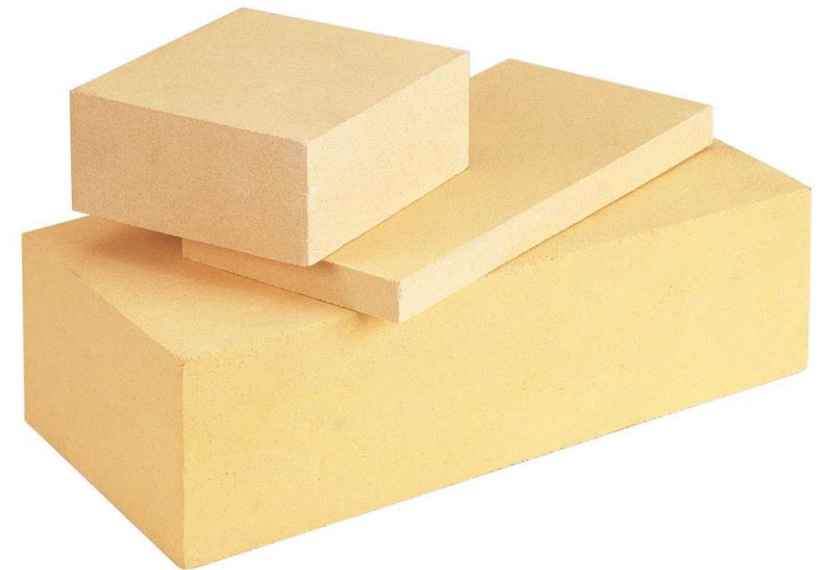
Tayler Perrey

5/13/2025

Overview



- Introductions
- What is zirconia?
- Zirconia in carbon black reactors
- Advantages of zirconia
- Zirconia refractory failure modes
- Zircoa in carbon black industry



Introductions



Tayler Perrey

M.S. Ceramic Engineering

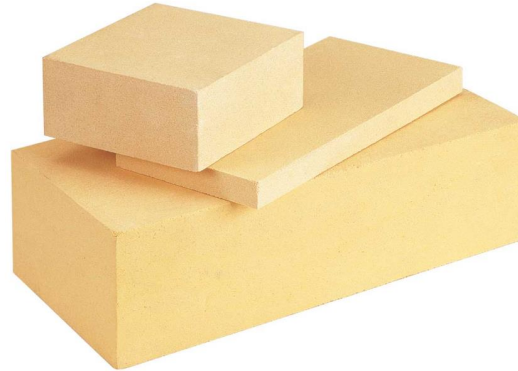
Application and Development Engineer

- SME – Carbon Black
- SME – Failure Analysis
- New composition development
- 14 years in ceramic industry
 - 6+ years with Zircoa



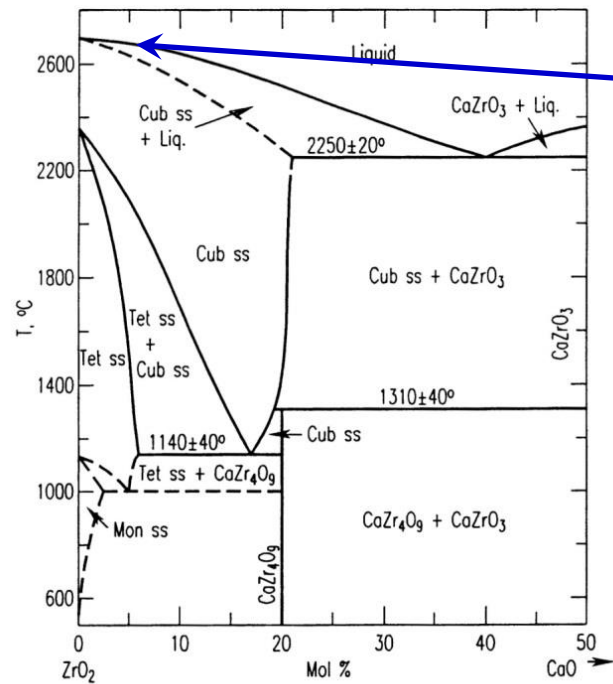
Zircoa

- Founded in 1952
- Headquarters based in Solon, Ohio (USA)
- Zircoa GmbH, Germany
 - Sales office responsible for EMEA+India
- Specializes in zirconia production for a variety of applications/industries
- ISO 9001:2015 with design

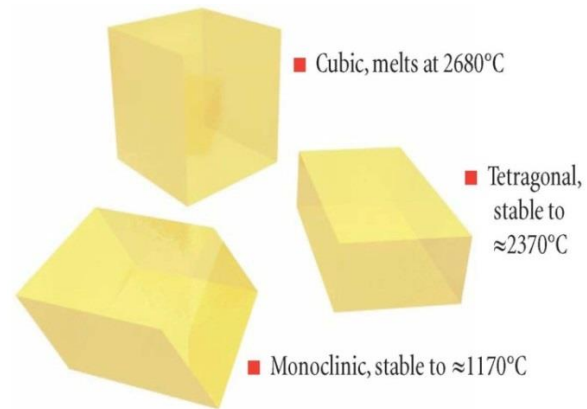


What is Zirconia (ZrO_2)?

Unique ceramic material that can be tailored to meet extreme conditions required to enable and/or improve industrial process.

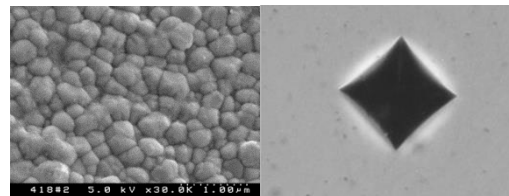
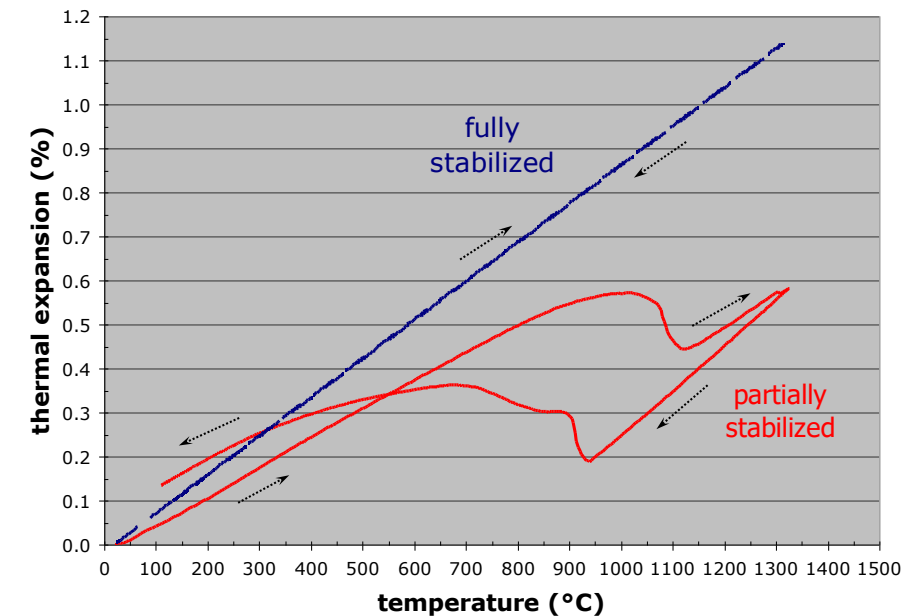


Very High-Temp Capability



Low Thermal Conductivity
Thermal Insulation

Thermal Shock Resistance



Texture
Toughness
Hardness
Mechanical Strength

Zirconia in Carbon Black Reactors

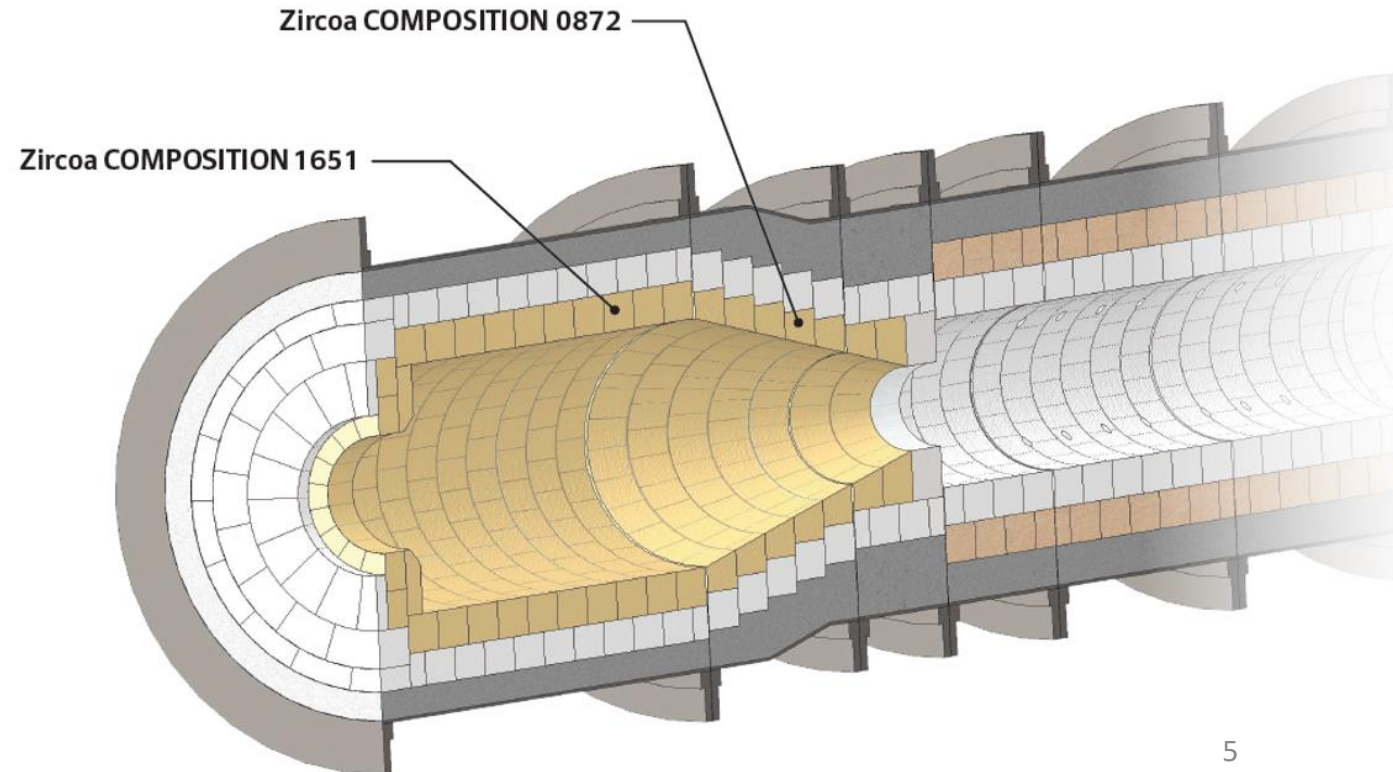


- Unique material properties of zirconia -> most demanding applications
- Hot face lining in combustion chamber

ZIRCOA PRODUCT OPTIONS

Zircoa COMPOSITION 1651 — Zircoa's premium calcia-stabilized pressed shape. Stable at temperatures greater than 3800°F (2100°C). With proven refractoriness for extreme temperatures, and 2 times the insulating value of alumina, Zircoa 1651 will take the heat.

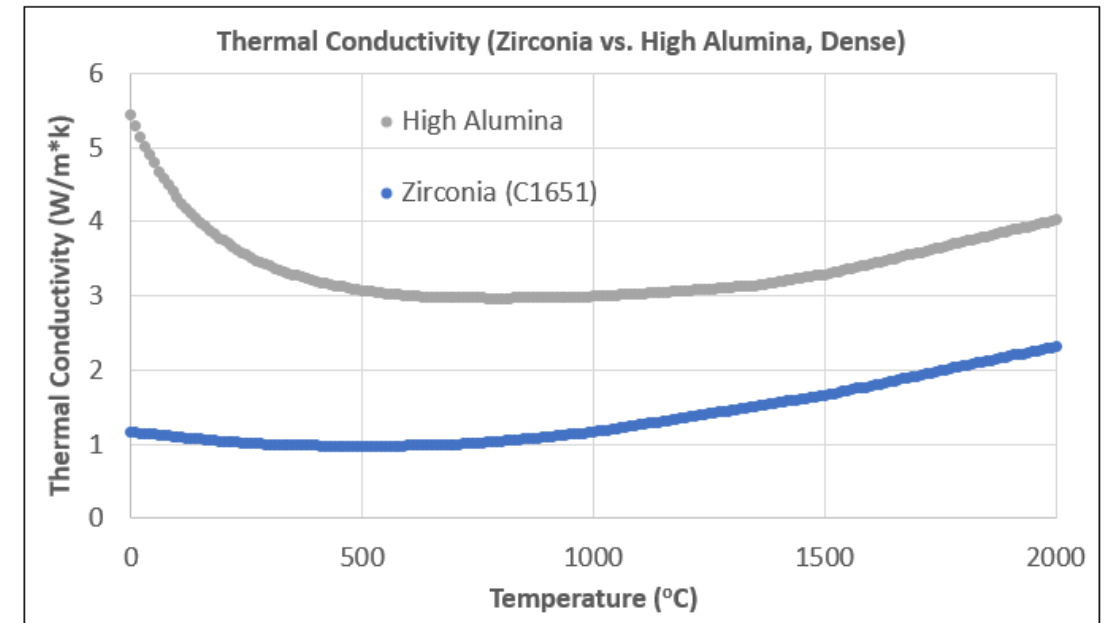
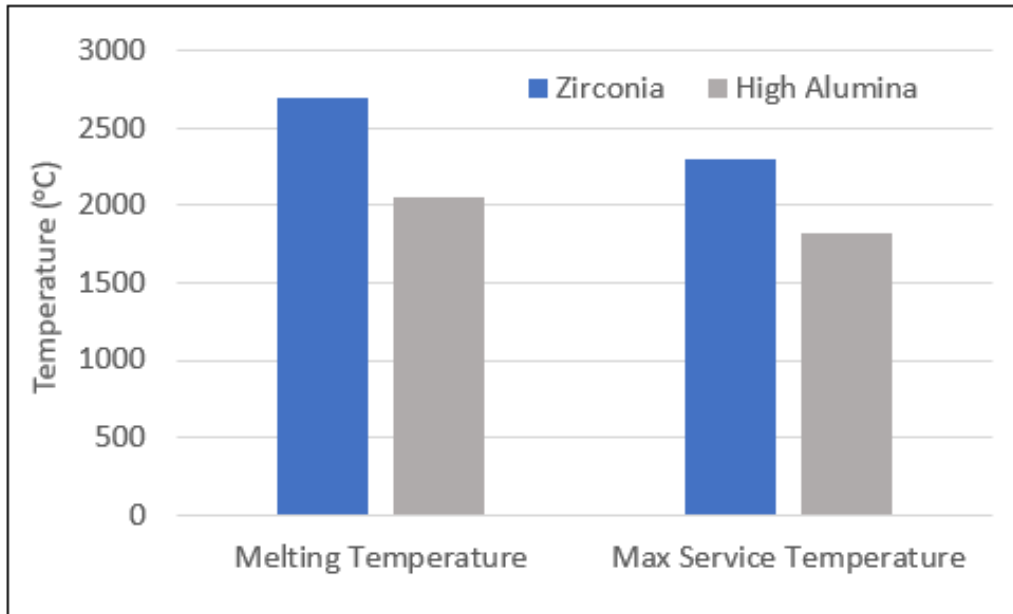
Zircoa COMPOSITION 0872 — Zircoa's calcia-stabilized, pre-fired, custom shapes formed with performance characteristics of Composition 1651. Frequently used in applications requiring complex geometry where brick installation can be time consuming.





Advantages of Zirconia in Carbon Black Reactors

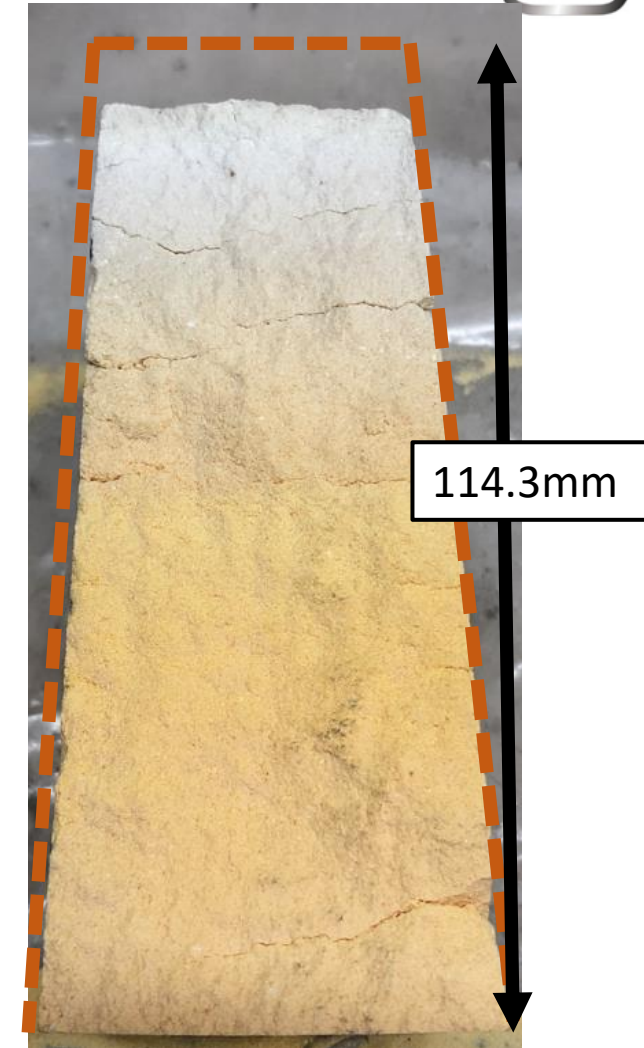
- Enables higher sustained reactor temperature ($>2150^{\circ}\text{C}$)
 - Higher reactor efficiency \rightarrow increased product yields
- $>40\%$ Lower thermal conductivity than high alumina at 2000°C
 - Retain more heat in the combustion chamber



Advantages of Zirconia in Carbon Black Reactors



- Erosion resistant:
 - Minimal loss of material over lining life
- Chemical inertness:
 - Reduced impact from aggressive process gasses
 - Potentially unlocking new products/grades
- Structural stability:
 - Maintains strength integrity at processing temperatures

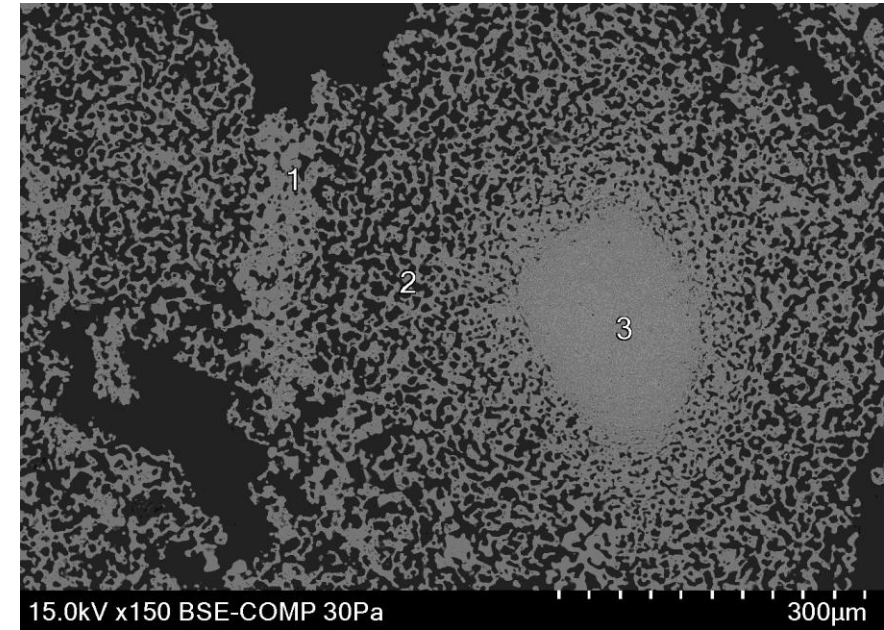


Cross-section of a zirconia brick (C1651)
after 2 years in carbon black reactor

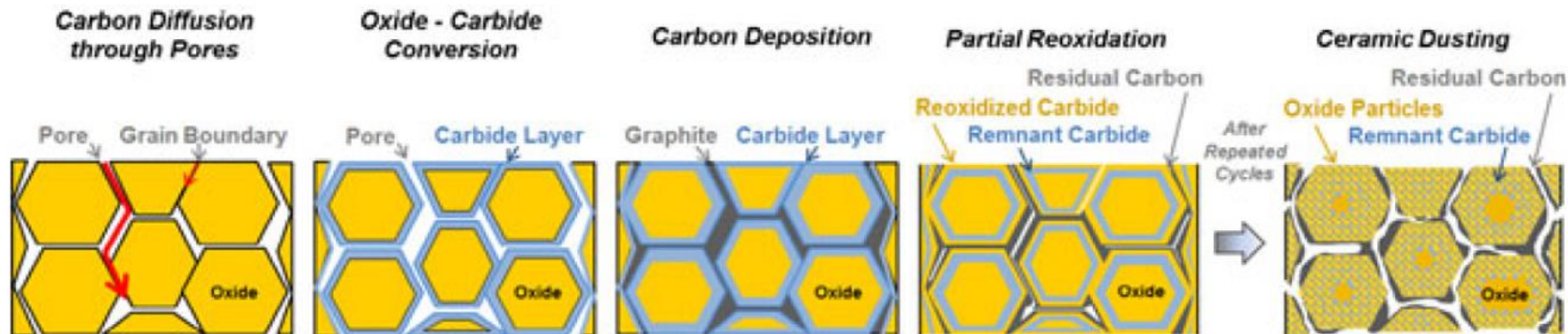


Zirconia Refractory Failure Modes

- Zirconia refractories do have limitations
- Unique microstructure observed after a failed customer trial
- Numerous cycles between oxidizing and reducing atmospheres, in carbon rich environment, at process temperature cause zirconia degradation



Degradation of fused ZrO_2 Grain



"Ceramic dusting" degradation mechanism (Chun, et al) [2]

Zirconia Refractory Failure Modes



Alkali attack

- Zirconia can degrade when in direct contact with alkali solution (potassium carbonate) at process temperatures
- Injector alignment and placement is critical to maximize lining life

Thermal shock

- As with all ceramics, sensitive to rapid and excessive temperature changes
- Avoiding hard shutdowns extends lining life



Early failure of zirconia lining due to injector mis-alignment

Zircoa in Carbon Black Industry



- 15+ years experience in carbon black industry
- Designed hot face linings for multiple reactor designs and customers
- Zircoa lining achieved 4.5 years life in carbon black reactor
- Continuous improvement through Application Engineering and partnerships
 - Thermal modeling software
 - Postmortem Analysis

*Zircoa's Mission: **Innovate** and **manufacture** specialty **zirconia** for the industry*

“Delivering what Matters”



**Thank You for
your attention!**



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