Industrial Materials For The Future

Project Fact Sheet

Characterization and Structural Modeling of Magnesia-Alumina Spinel Refractories

Benefits

The results from this project can be used by glass manufacturers and furnace and process heating designers to further accelerate the conversion to oxy-fuel firing and to achieve enhanced energy efficiencies and environmental improvements.

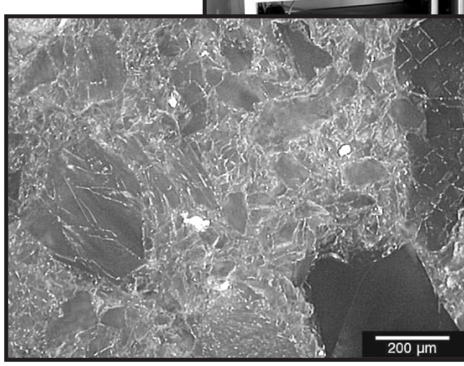
Applications

Engineering creep data for refractories can be used by furnace engineers as input in finite element analysis to model or optimize the long-term mechanical performance of glass-melting furnace superstructures. Data for candidate refractories for oxy-fuel-fired furnaces will help engineers optimize furnace superstructure designs with these materials and will help them to more confidently consider the conversion to oxy-fuel firing. Industries impacted include

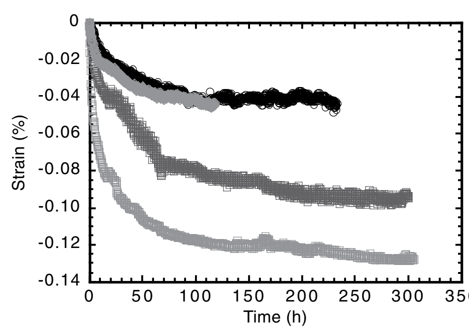
- **Aluminum**,
- **Glass**,
- **Meltalcasting**,
- **Heat Treating**, and
- **Process Heating**.

Spinel refractories offer improved high-temperature creep and properties

Furnace designers and furnace/refractories engineers recognize that more optimum furnace superstructure design and the use of appropriate refractories are needed as glass production furnaces are continually driven toward greater output and energy efficiencies (and concomitant harsher operating conditions). The conversion to oxy-fuel from traditional air-fuel firing is a means to meet these objectives. Refractories for both oxy- and air-fuel-fired furnace superstructures are subjected to high temperatures during service and may appreciably creep or subside if the refractory material is not creep resistant or if it is subjected to high stress or both. Published engineering creep data are essentially nonexistent for almost all commercially available refractories used for glass furnace superstructures. Furnace designers can ensure that superstructure structural integrity is maintained or predicted if the creep behavior of the refractory material they are using is well understood and well represented by appropriate engineering creep models.



Cathodoluminescent imaging of MgO refractory showing fused mullite grains (dark gray), trace amounts of alumina (light gray), and zirconia particles (bright white).



Project Description

Goal: The goal of the project is to characterize key properties of refractory materials to improve thermal efficiencies and management in industrial combustion environments.

Issues: A major barrier to the utilization of oxy-fuel-fired furnaces is that the higher operating temperatures in an oxygen-rich environment increase the rate of deformation (creep) and hasten alkali-induced corrosion. This had led to problems of unexpected failures of the crown refractories and an increased number of glass defects due to corrosion. This necessitates that both creep-resistant and corrosion-resistant refractories be used in furnace superstructures. One potential solution to these problems involves the use of new refractories, including magnesia-alumina spinel, which is now available in bonded and fused versions. This project seeks to determine reliable thermomechanical and thermophysical data for these new commercial refractories.

Approach: Physical and mechanical properties (including creep, thermal conductivity, microstructure, and phase composition) will be evaluated for two spinel glass tank crown refractories. This information will then be used to model and validate the long-term reliability of glass tank crowns.

Potential payoff: More efficient and economical designs of glass-melting furnace superstructures will result, and furnace engineers will know which refractory materials perform better than others and how to model the high-temperature mechanical performance. The result will be more energy-efficient furnaces and industrial processing systems. If implemented, energy savings of 90 trillion Btu/year could be realized.

Progress and Milestones

- Modify creep test frame design and operations.
- Acquire test specimens.
- Finalize test matrix for the spinel refractories.
- Complete creep testing and measurement of thermal properties.

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