Novel Refractory Materials for High-Temperature, High-Alkaline Environments

New Materials and Maintenance Techniques to Increase Efficiency of Furnaces and Process Vessels

The use of conventional refractory materials is limited by factors which reduce process energy efficiency, such as: chemical reactions, mechanical degradation by the service environment, temperature limitations, and costly installation and repairs. Degraded refractory insulation increases process heat loss and frequent maintenance requires cooling and reheating of the furnace or refractory, which result in additional energy losses and reduced productivity.

This project is developing a new family of refractory compositions tailored for use in high-temperature, high-alkaline industrial environments. Novel spinel and other magnesia and alumina containing materials will utilize new aggregate materials, bond systems, protective coatings, and phase formation techniques. The project’s team is using both refractory development experience and computer modeling techniques to design the new materials. The team is also developing new application techniques and systems to optimize installation, maximize lining properties, and facilitate hot installation and repairs.

Benefits for Our Industry and Our Nation

The newly developed materials are expected to offer alternative choices for high-temperature, high-alkali environments that may be capable of operating at higher temperatures or for longer periods of time. This will lead to less process down time, greater energy efficiency as more heat kept in associated manufacturing processes, and materials that can be installed/repairied in a more efficient manner. The project goal is a 5% improvement in the energy efficiency of the overall process (such as aluminum melting, black liquor gasification, coal gasification, glass melting, or lime processing) through the implementation of materials that would result in a 20% improvement in thermal efficiency of the process (more heat available for use). This could be accomplished by using materials with lower thermal conductivity (less heat losses through furnace walls), materials that do no corrode or erode, or by using materials that can operate at higher temperatures (resulting in more process throughput and less time for load in the furnace).

Applications in Our Nation’s Industry

By decreasing the amount of waste heat and extending furnace life times, the materials developed in this project could help increase the overall efficiency of furnaces and process vessels used in the aluminum, chemical, forest products, glass, and steel industries.

Project Description

The objective of the project is to address the need for new innovative refractory compositions by developing a family of novel MgO-Al₂O₃ spinel or other similar alumina and magnesia containing unshaped refractory compositions (castables, gunnables, shotcretes, etc.) utilizing new aggregate materials, bond systems, protective coatings, and phase formation techniques.

Barriers

Major barriers include the following:

- Lack of refractory compositions with reduced susceptibility to reactions and mechanical degradation between the service environment and the refractory material
- Lack of installation techniques and processes for the application of newly developed refractories
- Lack of a broad suite of options for on-line (hot) maintenance
Pathways
The objectives of the project are being achieved by: (1) measuring and comparing key properties of currently used refractory materials; (2) developing a family of novel magnesium aluminate containing unshaped refractory materials; (3) measuring and comparing key properties of the newly developed refractory materials; (4) developing new refractory application techniques; and (5) creating a comprehensive database concerning currently used and newly developed refractory materials.

Milestones
• Develop four new refractory materials for applications in the four target industries (Complete)
• Develop new refractory application techniques (Complete)
• Develop hot repair techniques which will lead to energy savings by reducing the need to shut down or fully cool refractory lined vessels to repair failed or deteriorating refractories (Complete)
• Develop a database of data collected from the development of new refractory application techniques
• Obtain six months of in-plant operating experience at industrial partner locations

Commercialization
Four industrial partners from the aluminum, chemical, glass, and pulp and paper industries have been a part of the project from its inception, providing insight about the commercial viability of the materials being developed and guidance about possible industrial trial sites for validation of the materials in the last year of the project. Technologies developed in the laboratory during the first three years of the project are currently being produced on an industrial scale and installed in industrial settings. To date, over 30 tons of refractory material have been installed in various industrial furnace trials expected to last six months to a year in duration. Additionally, lead industrial partner MinTeq, International is leading the effort to extend the materials developed under this project to the market place through their standard commercialization practices.

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