Background

Refractory castables are advanced materials used in high-temperature industries. Unlike traditional bricks, they are applied as a wet mixture that hardens into a solid form. Among these castables, no-cement castables are valued for their fast drying time and excellent heat resistance.

After application, the materials undergo a critical "dry-out" phase, where external heat is applied to remove the water used to provide the initial rheology. As the material transitions from a hydraulic bond to a ceramic bond, significant water vapor is released. If the vapor is produced faster than it can escape through the material's pores, internal pressure builds, leading to explosive spalling. The risk is particularly high between 250-450°C, where pressure peaks, posing serious safety hazards for workers and equipment.

Currently, drying processes are monitored using thermocouples, which measure temperatures on the surface or within the material. However, thermocouples cannot detect internal steam pressure, the primary driver of explosive behavior. Previous efforts to address this gap resulted in technologies that were either too invasive or incompatible with specific systems.

Developing a disposable pressure sensor embedded into the monolithic refractory could provide critical data on internal pressure during heating. This information would allow operators to adjust external heat levels as needed, giving trapped steam enough time to escape and preventing dangerous pressure buildup. By reducing the risk of explosions, this innovation would enhance safety and support the wider adoption of monolithic refractories in high-temperature industries.

What we're looking for

We are seeking partners to collaborate on developing a disposable, miniaturized pressure sensor designed to be immersed in monolithic refractories (castables) to monitor steam pressure buildup during the curing/heating process, which occurs at temperatures of up to 500°C or 750°C. Ideal partners are researchers and organizations with experience in developing these types of sensors and interested in advancing their application to withstand high-temperature environments.

Solutions of interest include:

- Piezoelectric sensors
- Strain gauge sensors
- Capacity pressure sensors
- Silicon-on-insulator (SOI) sensors
- Fiber-optic pressure sensors
- Ceramic pressure sensors

Our must-have requirements are:

- Ability to transmit signals via radio to an external receiver/recorder device
- Size compatible with the refractory matrix (max 50 mm)
- Withstands incorporation into refractory concrete and resists temperatures up to 500°C
- Ability to measure absolute pressure up to 10 bar (2-3 bar for the testing phase)

Our nice-to-have's are:

- Resists temperatures up to 750°C.
- Ability to measure absolute pressure up to 50 bar.
- Ensures functionality throughout the 30-hour concrete setting process, enduring harsh environments and all hardening phases.
- Compact size, ideally between 20 and 25 mm.
- Electronic components mounted on alumina or alternative durable materials to ensure safety and functionality in extreme conditions.
- Incorporates a built-in temperature sensor for simultaneous monitoring of internal temperature and pressure during the curing process.

Acceptable technology readiness levels (TRL): Levels 3-9

1. Basic principles observed

2. Concept development
3. Experimental proof of concept
4. Validated in lab conditions
5. Validated in relevant environment
6. Demonstrated in relevant environment
7. Regulatory approval
8. Product in production
9. Product in market

What we can offer you

Eligible partnership models:

Sponsored research
Co-development
Supply/purchase

Benefits:

Sponsored Research

Up to $100,000 for a proof-of-concept, with additional potential funding for further development.

Facilities and Services

Potential for participation in large-scale projects and plant trials.

Please contact the University of South Florida Technology Transfer office representative for submission – Karla Schramm at kschramm@usf.edu