Calderys provides a look at the role of refractories in decarbonisation and advancing green cement production.

As the global cement industry intensifies its focus on sustainability and decarbonisation, the role of refractories in supporting these efforts has become increasingly vital. With stricter environmental regulations and growing demand for green cement, refractory manufacturers are developing innovative solutions to address the unique challenges posed by alternative fuels (AFs) and new production technologies.

As a primary supplier to some of the world's largest cement producers, numerous experts within Calderys Group (which includes its EMEA and APAC operations and HWI, a member of Calderys in the Americas) are working to support cement customers' goals to reduce their carbon footprint.

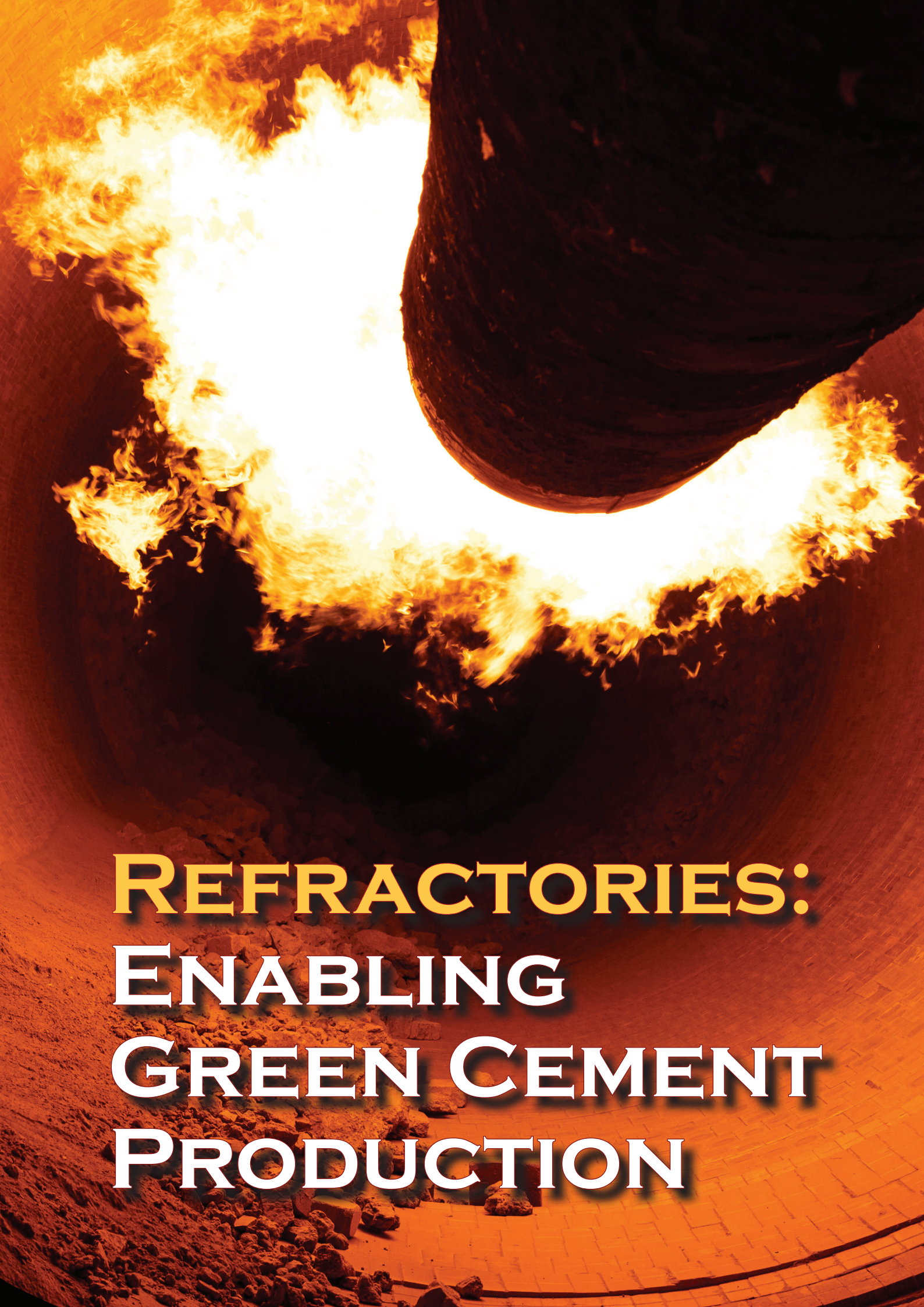
This article examines how the refractory industry is adapting to support cement producers' sustainability goals, highlighting key innovations, case studies, and collaborative efforts with the company's cement customers globally.

The challenge of alternative fuels

One of the primary strategies cement producers employ to reduce their carbon footprint is the increased use of AFs. While offering environmental and cost benefits, AFs introduce new challenges for refractory materials used in cement kilns. The varying chemical compositions and inconsistent burn profiles of these fuels create more aggressive environments within kilns, demanding higher performance from refractories.

In India, the rise of AFs like petcoke, sewage sludge, and municipal solid waste in cement kilns presents both economic benefits and significant challenges for refractory materials. The fluctuating quality and chemical composition of these fuels creates extreme conditions within the kiln, demanding advanced solutions.

The challenges posed by AFs include chemical attacks from sulfur and chlorine, thermal shocks due to inconsistent burn profiles, and intensified



Refractories: Enabling Green Cement Production

corrosion and abrasion from volatile compounds. These factors significantly reduce the lifespan of refractory linings.

To address these issues, Calderys developed the SUPRAMON HS series, chemically bonded castables specifically designed for kilns utilising AFs. SUPRAMON HS (SS 37) offers enhanced chemical resistance, superior mechanical properties, and improved thermal stability. The inclusion of nano-sized particles and a mullite matrix strengthens its resistance to chemical attack, while its high cold crushing strength ensures better abrasion resistance. Additionally, its optimised formulation provides enhanced spalling resistance, which is crucial for maintaining kiln lining integrity against thermal shocks.

Field results from cement plants in Rajasthan, India, and Riyadh, Saudi Arabia, which utilise high percentages of petcoke, demonstrate significantly extended refractory life in critical areas such as the calciner cone and smoke chamber.

Refractories are an integral element in cement operations, and their role in producers' decarbonisation efforts is significant.

The riser area of the preheater tower where build-up and mechanical wear from removing the build-up were problematic. This photo was taken after one year in operation.

The SUPRAMON HS series has proven to be a reliable, high-performance solution for cement manufacturers aiming to optimise kiln operations and tackle the challenges posed by AFs, ultimately enhancing efficiency and profitability.

In Turkey, the shift towards AFs in cement production has introduced significant challenges, particularly with alkali-related wear on refractory materials. To address these issues, Haznedar Durer Refractories, a member of Calderys, developed HAZAL T2 AR, a refractory brick designed to withstand the harsh conditions caused by AFs without relying on costly materials like silicon carbide or zircon.

HAZAL T2 AR is characterised by its low porosity, high durability, and enhanced resistance to alkalis, wear, thermal shock, and acid gases. Unlike conventional alumina silicate refractories, this refractory brick can effectively handle the severe chemical and thermal stresses that arise when using waste materials as fuel or raw materials in cement production.

The brick's development was driven by the need for a cost-effective solution that could be deployed across all stages of the cement production process, where alkali and abrasion resistance are crucial. Since its first industrial trials, HAZAL T2 AR has demonstrated superior performance in various sections of cement plants, including rotary kilns, coolers, pre-heaters, and calciners. Its effectiveness in mitigating sticking problems in rotary kiln transition chambers has also been particularly noteworthy.

Since 2014, it has become the most widely used refractory product in the cement industry for Haznedar, proving its value as a robust and versatile solution for modern cement manufacturing.

Proactive refractory management

In North America, the transition to AFs like tyres and car fluff has presented significant challenges for cement manufacturers, particularly in managing the wear on refractory materials. The technical applications team at HWI has recognised that the infiltration of SOx gas, alkali sulfates, and chlorides from these industrial fuels poses a serious threat to the structural integrity of magnesia-spinel and high-alumina refractories. These compounds react with the refractory materials, weakening their bond structure and altering thermo-physical properties, leading to thermal shock, spalling, and increased shell temperatures.

Wear mechanisms, particularly in the lower preheat tower and kiln inlet, create build-up and blockages that exacerbate refractory degradation. The cycle of evaporation and

condensation of volatile compounds, such as Cl, K_2O, Na_2O, and SO_3, further intensifies the alkali attacks, leading to densification and bloating of the refractory, which can stress kiln components and lead to structural failures.

To mitigate these effects, it is crucial to proactively assess the current state of refractories, including 'half-life' samples, to understand wear mechanisms and plans for refractory replacements before unplanned shutdowns occur. Techniques like X-ray fluorescence spectrometry, X-ray diffractometry, and scanning electron microscopy are essential in identifying chemical changes and phase interactions within the refractory.

In response to service environments, where ultimate resistance to alkali attack and protection from build-ups are required to maintain stable operation, HWI introduced its THORBIDE family of products. They target processes utilising high levels of AFs or raw materials where aggressive alkali attack is the primary wear mechanism. Additionally, the physical properties of THORBIDE provide enhanced strength for mechanically stressed areas, making it well suited for application in rotary kilns and stationary vessels.

Engineered with a balance of materials and grain sizing, THORBIDE products have been developed to improve plant operations, specifically targeting areas of build-up and alkali attack.

THORBIDE brick provides enhanced resistance to the toughest of service environments where mechanical stresses limit the service life of traditional 50% alumina brick.

By applying a deep understanding of cement producers' operations, HWI has helped manufacturers navigate the challenges of AFs to optimise refractory linings and maintain production efficiency during energy transitions. These best practices and product solutions emphasise the importance of understanding current refractory conditions and planning ahead to avoid unexpected shutdowns.

The drop wall of the cooler where alkali attack was problematic. The customer struggled with replacing this area annually. The photo was taken after one year in operation and was left in service for another campaign.

Enabling new low-carbon technologies

In Europe, the cement industry is embracing new low-carbon production technologies. Refractories are participating in these advancements and extending their role beyond supporting AF use. As the industry explores innovative fuels like hydrogen and seeks to adopt advanced operating concepts such as oxyfuel combustion, calcium looping, and calcined clay, refractory suppliers must adapt and innovate to meet these emerging challenges.

In particular, hydrogen and oxyfuel combustion impose higher thermal loads on refractories, necessitating the development of higher-grade materials to withstand these extreme conditions. Drawing on experience from other industries that use hydrogen thermal processes, Calderys and other refractory suppliers are involved in industrial-scale studies to assess the long-term impact of these new technologies on refractory performance.

An essential part of this innovation cycle involves conducting detailed post-mortem analyses of used refractories. These examinations are vital for understanding the durability of materials under new operational stresses and serve as a foundation for improving refractory service life. As the cement industry advances toward decarbonisation, these efforts will ensure the longevity and efficiency of refractory solutions in this evolving landscape.

Global collaboration and innovation

The challenges posed by the cement industry's sustainability push are driving increased collaboration between refractory suppliers, cement producers, and research institutions worldwide. This collaborative approach yields innovative solutions and accelerates the development of new technologies.

Calderys' global presence and recent collaboration with HWI is enabling a broader portfolio of solutions to be offered to cement producers worldwide. Customers now benefit from HWI's process knowledge, extensive technical support, comprehensive product portfolio, Calderys' monolithic refractories optimised for facilities, high alumina bricks from the Haznedar plant near Istanbul, and prefabricated parts.

As the demand for green cement continues to grow, the refractory industry will undoubtedly continue to innovate and adapt. By working closely with cement producers and staying at the forefront of technological developments, refractory manufacturers like Calderys are helping to shape a more sustainable future for the global cement industry. ■