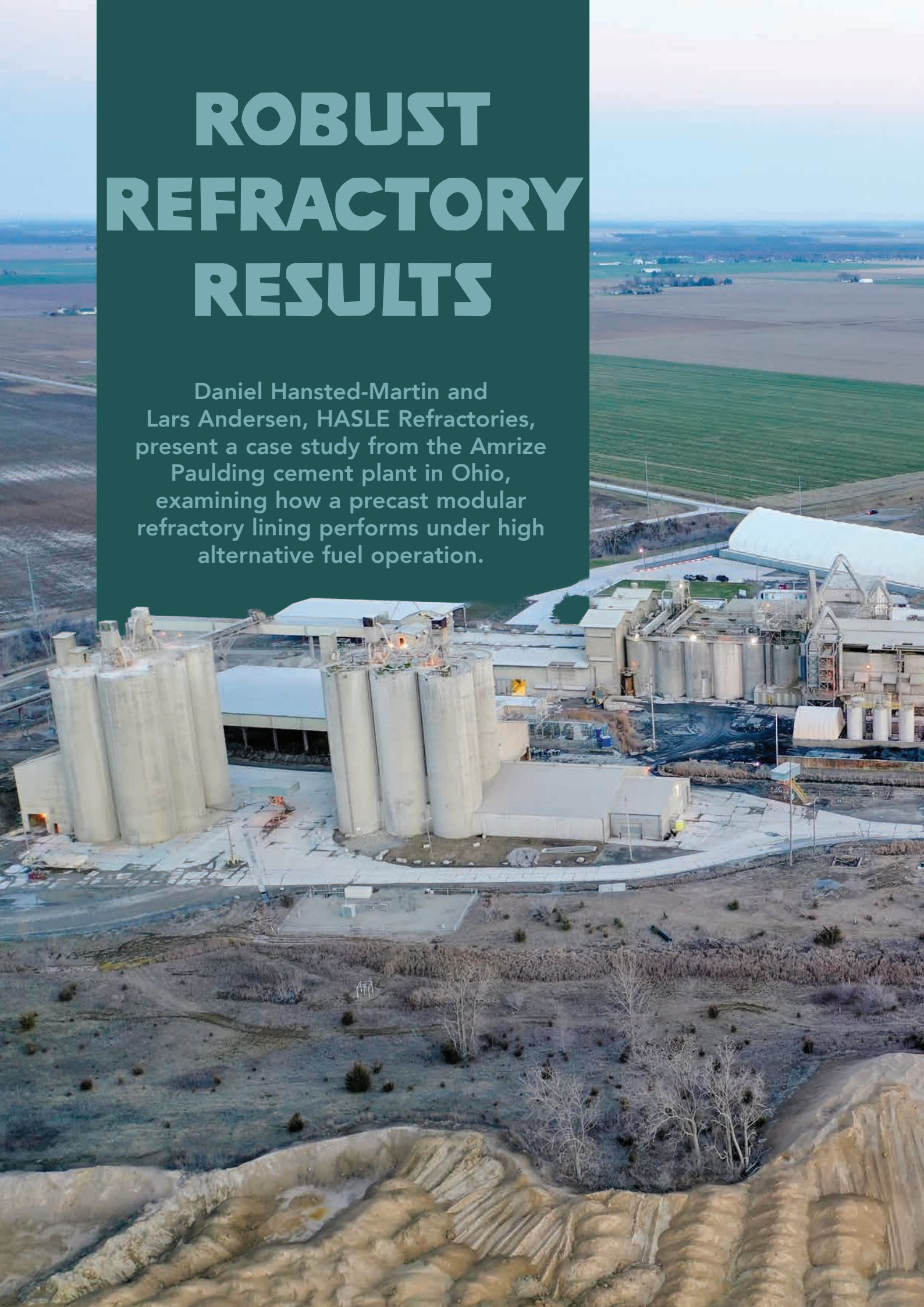



ROBUST REFRACTORY RESULTS

Daniel Hansted-Martin and
Lars Andersen, HASLE Refractories,
present a case study from the Amrize
Paulding cement plant in Ohio,
examining how a precast modular
refractory lining performs under high
alternative fuel operation.





Amidst open farmland in Paulding, Ohio, just south of the Great Lakes region, sits the Amrize Paulding cement plant – an integrated manufacturing facility that produces the high-performance cement that the built environment relies on. Constructed in 1956, the plant is a long-established site serving local and regional markets across the US Midwest. Surrounded predominantly by agricultural land, it benefits from direct access to raw materials while maintaining close proximity to its core customer base in northwestern Ohio, with distribution extending to areas such as Columbus and northern Indiana.

The facility operates two identical long wet-process rotary kilns, each with a maximum rated clinker capacity of approximately 820 tpd, corresponding to an actual clinker production of roughly 330 000 tpy. Each kiln measures approximately 425 ft (130 m) in length with a diameter of 11 ft 3 in. (3.5 m) and includes an extended ~100 ft chain section to support heat transfer and material drying. Clinker cooling is carried out using first-generation reciprocating grate coolers, while the kiln system is equipped with selective non-catalytic reduction (SNCR) for NO_x control.

A distinguishing feature of the Paulding plant is its vertically integrated raw material supply. All essential components of the raw mix are quarried on site from a deposit of Dundee limestone. Minor corrective materials include sand

sourced from a nearby foundry operation and alumina-rich materials added as availability permits. In addition to cement production, the plant supplies agricultural lime to local farmers, further strengthening its ties to the surrounding rural community.

Multi-faceted innovation and sustainability approach

Alongside its clinker production activities, the Paulding plant applies a multi-faceted and innovative approach to sustainability that combines energy, environmental, and community-focused initiatives. In 2018, three wind turbines were commissioned, generating approximately 4.5 MWh of renewable electricity per year and covering roughly 30% of the plant's total electrical demand. The wind project significantly reduces indirect CO₂ emissions, complemented by active engagement through local partnerships with schools and other educational initiatives, demonstrating Amrize Paulding's commitment to investing directly in the communities it operates within.

Long-standing alternative fuel leadership

Alternative fuel (AF) utilisation has been a defining element of the Paulding plant for more than four decades. Co-processing of waste-derived liquid fuels began as early as around 1980, placing the plant among the early pioneers of AF use in the North American cement industry.

Since then, this capability has been continuously expanded and refined, enabling not only very high substitution

rates but also long-term operational stability.

Over the past decade, the plant has consistently operated at average thermal substitution rates (TSR) above 95%, an achievement that remains exceptional even by global benchmarks. Within this period, individual months have reached near-total fuel replacement, including reported values approaching 100% TSR (≈99.8%). Maintaining such levels on a sustained basis requires a high degree of process control and operational discipline, particularly in a wet-process kiln configuration.

Liquid waste-derived fuels are processed and conditioned through a dedicated, on-site fuel preparation operation located within the plant. Incoming fuels are delivered by both rail and truck, undergoing systematic testing to verify environmental compliance and key combustion characteristics, including calorific value and water content. Typical fuels comprise liquid industrial by-products, including hazardous waste streams, sourced from a wide range of manufacturing sectors and exhibit significant variability in composition. Notably, the fuel streams often contain elevated moisture levels that introduce additional thermal and chemical challenges to kiln operation.

Intense refractory wear

The combination of long wet kilns, sustained near-100% AF operation, high fuel moisture, and high utilisation rates creates a particularly demanding operating environment for the refractory linings at the Paulding plant. Thermal cycling, variable flame characteristics, and fluctuating



The Amrize Paulding cement plant in northwestern Ohio is located amid predominantly agricultural farmland. The integrated facility operates two long wet-process rotary kilns with a combined clinker capacity of approximately 820 tpd and includes on-site limestone quarries supplying the plant's raw material requirements.

chemical species, such as alkali and sulfur inputs, intensify wear mechanisms.

These effects are particularly prevalent in the burning zone, kiln outlet, and the transition to the grate cooler, where refractories are exposed to high radiant heat from the clinker bed, fluctuating temperature gradients, and mechanical impact and abrasion from clinker discharge. In this zone, even moderate increases in fuel moisture or variations in combustion behaviour can significantly accelerate lining degradation, making refractory performance a key factor for operational reliability.

While the previously installed lining delivered acceptable service performance under these conditions, the plant identified an opportunity to further improve lining durability and reduce maintenance demand in this critical transition area. Against this backdrop, a refractory lining concept for the kiln hood and cooler throat was identified, providing enhanced durability and stable long-term performance under sustained high AF utilisation.

Precast lining as a durable alternative

As an alternative to in-situ cast solutions, HASLE Refractories proposed a precast lining based on its modular lining concept. Originally developed in the 1990s, this system is designed as a hot-face refractory solution for critical zones in high-temperature industrial applications, based on standardised 25 × 25 cm precast elements.

The precast elements are characterised by high mechanical strength and a smooth impact surface, which helps minimise abrasion and coating formation while providing excellent resistance to chemical attack. Flexible anchoring allows the lining system to be adapted to plant-specific geometries, lining thicknesses, and insulation requirements, enabling optimisation of both mechanical performance, throughput, and thermal efficiency.

All modular lining elements are manufactured under strictly controlled conditions at HASLE's production facility in Denmark, using exclusively virgin raw materials to ensure consistent quality. The production process includes casting on vibration tables using precision moulds, followed by controlled drying and pre-firing. The green precast bodies are pre-fired



With AF co-processing established since the early 1980s, the Amrize Paulding cement plant operates liquid AF storage and handling systems that enable sustained TSR above 95%, at times approaching 100%.



As part of a multi-faceted sustainability approach, three wind turbines commissioned in 2018 supply approximately 30% of the Amrize Paulding cement plant's electricity demand, reducing indirect CO₂ emissions and supporting long-term energy efficiency.

over several days to a peak temperature of approximately 500°C, ensuring complete removal of free and chemically bound water. This process results in a very low



Installation of HASLE precast modular lining in the cooler throat and kiln hood at the Paulding cement plant.



Completed installation of the first section of the cooler throat and kiln hood walls with the HASLE precast modular lining system.



Inspection during a scheduled shutdown in March 2025. The precast lining remains in service and continues to perform as intended. In 2026, the lining remain in service.

open porosity of 8 – 10%, producing a dense, impact-resistant hot-face surface.

The refractory composition features an optimised grain size distribution, contributing to high density and robustness. Combined with the material's inherent resistance to chemical attack – including exposure to alkalis, sulfates, and chlorides – this dense matrix provides effective protection against both abrasion and chemical corrosion in demanding operating environments.

The system further incorporates a flexible steel anchoring arrangement together with an interlocking tongue-and-groove design integrated into the precast elements. This combination supports mechanical stability, accommodates thermal movement, and simplifies installation. In addition, the thermal performance of the lining can be tailored by selecting suitable backup insulation materials – such as ceramic fibre blankets or insulating castables – behind the precast hot face, allowing heat transfer characteristics to be adapted to plant-specific requirements.

Translating design into on-site performance/installing a layered lining solution

The precast lining system was installed in July 2023 in the kiln hood and cooler throat transition zone of one kiln line, covering a total area of approximately 50 m². The installation was carried out during a scheduled shutdown and formed part of the plant's efforts to improve lining durability and reduce maintenance requirements in this highly exposed transition area.

Individual precast elements, each weighing approximately 15 – 16 kg, allowed safe and efficient manual handling without the need for special lifting equipment, supporting flexible installation sequencing in the confined geometry of the kiln outlet area. During installation, the joints between adjacent elements were filled with a 2 – 3 mm refractory mortar, creating a continuous hot-face surface and minimising the penetration of hot gases into the insulation layer and anchoring system behind the lining.

The lining was mechanically fixed using a steel rail and bolt anchoring system welded to the kiln casing. Length-adjustable bolts and sliding washers provided installation flexibility while allowing controlled movement during thermal expansion. To further accommodate thermal expansion within the precast lining system, ceramic

fibre layers were installed at defined intervals between lining sections, applied at approximately one-metre spacing.

Calcium silicate insulation boards were installed against the steel casing and between the steel rails. Following placement of the precast elements, HASLE BS1200 insulating castable was poured behind the hot face lining to complete the backup insulation. This multi-layer insulation system reduces heat transfer to the casing, retains heat within the pyroprocess, and provides additional protection to the steel structure. The resulting layered lining concept – combining a dense precast hot face, insulation boards, and a cast-in-place insulating backup – allows the lining to be tailored to the thermal and mechanical demands of the kiln-to-cooler transition zone.

The installation was carried out under technical supervision from HASLE, ensuring execution in accordance with defined installation procedures and alignment with the intended lining design.

Still going strong

Following the installation in the summer of 2023, the precast lining in the kiln hood and cooler throat transition has remained in continuous operation. A detailed visual inspection was carried out during a planned shutdown in March 2025, after almost two years of service.

At the time of inspection, the precast elements were found to be in good overall condition, with no indications of structural damage, excessive wear, or abnormal degradation. The hot-face surfaces remained intact and smooth, and original cast-in markings, including the HASLE logo, were still clearly visible on several elements – providing a clear visual indication

of limited abrasion and stable surface conditions. No corrective maintenance was required, and the lining was returned to service following the shutdown.

Today, the precast lining continues to perform as intended, supporting stable operation in one of the most demanding zones of the kiln system. The observed condition confirms that the modular precast concept provides a durable and low-maintenance lining solution for kiln hood and cooler throat applications.

The performance of the precast lining at the Paulding plant underscores that precast refractory solutions can provide durable and low-maintenance service in critical applications operating under sustained high AF substitution. The observed condition after extended service highlights the importance of lining concepts designed specifically for high-TSR operating environments. ■

About the authors

Daniel Hansted-Martin is Regional Manager at HASLE Refractories, where he leads the Copenhagen-based sales office with responsibility for the European and American markets. Daniel holds a Bachelor's degree in international management and brings extensive experience from on-site installations, along with an in-depth understanding of refractory challenges and solutions.

Lars Andersen is Product Line Manager at HASLE Refractories, Denmark. Lars holds a master's degree in mechanical engineering from the Technical University of Denmark and has over 25 years of experience in industrial equipment design and process optimisation for the cement industry.