Henrik Andersen, HASLE Refractories, discusses the role of refractory lining in clinker coolers, and explains how short lining lifetimes can be addressed with a specialised modular precast lining system.

RETHINKING REFRACTORY LINING

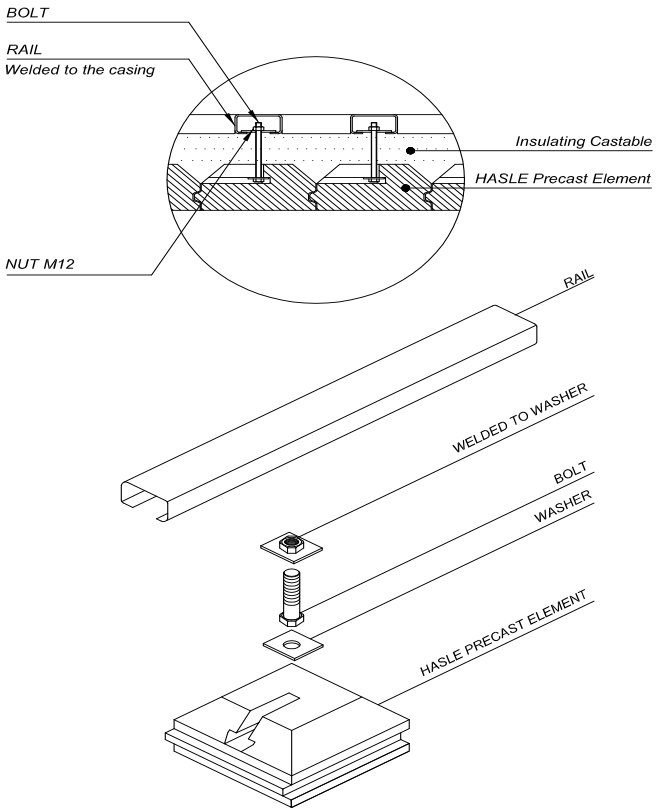
The clinker cooler plays a critical role in the cement manufacturing process by rapidly cooling the hot clinker leaving the kiln, thereby stabilising the C3S clinker phase and transforming the clinker into a manageable state for subsequent processing, grinding, and stable storage.

Sustaining uninterrupted cooler operation during production is essential, and a crucial component is a robust refractory lining. However, the cooling air that passes through the clinker exerts significant stress on the refractory roof lining, especially in the hottest part of the cooler. This stress comes not only from the impact of the hot air stream on the lining's surface but also from abrasion caused by dust and other particles suspended in the air. Additionally, the temperature fluctuations during operation contribute to thermal stress in the refractory lining, which can lead to issues like cracking and spalling.

Beyond its cooling role, the grate cooler is a critical tool for enhancing overall process efficiency by recovering thermal energy, thereby minimising the plant's environmental impact and optimising plant profitability. Strategies such as utilising secondary air in the kiln, introducing a tertiary air duct for heat reuse in the preheating process, or installing heat-recovery boilers, while beneficial, introduce complexity to the cooler's design and operation. This complexity involves creating openings in the roof for air ducts and outlets along with altering the flow field of the air, which

consequently also can change the abrasion and wear pattern on the lining.

While the primary cause of lining failure in the grate cooler is not usually attributed to the increased use of alternative fuels, the associated chemical attacks could potentially also impact lining lifetime, adding another layer of consideration to the durability of refractory linings in the area.



The HASLE precast Modular Lining System designed for roof applications. Enabling enhanced flexibility during installation, the precast elements interlock through tongue-and-groove joints. Each precast element is securely fastened with a bolt and washer, and smoothly slides into a steel rail welded to the roof casing. An insulating castable can be applied behind the precast elements for minimal heat loss.

HASLE Modular Lining during installation in 2018 in hot zone of the cooler roof at German cement plant. The relatively low weight of each precast element (15 – 16 kg), simplifies the installation process.

A short refractory lifespan not only leads to increased maintenance costs, encompassing materials and man-hours, but also poses the risk of extended downtime and reduced production output. Additionally, repairing or relining the roof lining typically involves substantial efforts and equipment, including tasks such as scaffolding, comprehensive formwork, or handling of heavy blocks.

Hot zone presents a particular challenge

The clinker, entering the cooler at a temperature of approximately 1200˚C, undergoes a crucial cooling process in the 'hot zone' of the grate cooler. In this zone, which usually spans from the downfall and into the first two compartments of the grate cooler, the primary objective is to rapidly cool down the clinker. The cooling rate not only impacts the crystalline structure of the clinker but also influences its grindability. Therefore, achieving fast cooling in the hot zone is essential for producing high-quality cement. However, this rapid cooling generates a hot air stream laden with particles, putting significant stress on the roof lining of that section of the cooler.

Consequently, a robust roof lining that withstands both abrasion and thermal shocks becomes imperative for ensuring a prolonged lining lifetime.

As the clinker travels down through the grate cooler into the 'cold zone', characterised by clinker temperatures below 800˚C, ensuring a uniform temperature reduction throughout the clinker body becomes central. In this section, the primary concern shifts to the impact of abrasion on the refractory lining.

Durable and customised precast solution

As an alternative to traditional in-situ castings, the HASLE precast Modular Lining system includes roof, wall and angled elements for applications throughout the clinker cooler. The lining system is based on standardised 25 x 25 cm precast shapes, weighing only 15 – 16 kg each, meaning no special lifting equipment is needed during installation. Moreover, this modular system design facilitates easy customisation to suit the specific requirements of the cooler design.

To achieve the highest quality, the precast elements are composed exclusively of virgin materials. The key to the exceptional strength lies in an optimised grain size matrix.

This careful composition renders the precast elements exceptionally robust,

endowing them with excellent resistance to abrasion. Further, leveraging the refractory material's high resistance to chemical attacks from both alkali, sulfates, and chlorides, the precast solution effectively minimises corrosion issues.

The Modular Lining is manufactured under strict controls at HASLE's facility in Denmark. Here, specialised casting equipment, such as vibration tables and tailor-made moulds, is used. The green precast bodies subsequently undergo a five-day pre-firing process, reaching a peak temperature of 500˚C. This carefully controlled procedure effectively eliminates all free and chemically-bound water, resulting in a low open porosity of just 8 – 10%, a marked improvement compared to the 15 – 20% typically found in in-situ cast linings of other materials. The outcome is an exceptionally smooth surface of the precast elements, boasting heightened resistance to abrasion.

From trial to lasting solution

In Germany, a 2300 tpd cement plant operating on 80% refuse-derived fuel (RDF) and 20% coal, faced a recurring challenge with a frustratingly short lifespan of the roof lining. Despite utilising precast shapes from another supplier, yearly replacements of the roof lining in the hot zone were the norm until they turned to HASLE for a lasting solution.

In pursuit of a more durable solution to withstand the challenging conditions of high temperatures, abrasion and usage of alternative fuels affecting the roof lining, the German cement plant opted to conduct a trial, using approximately 6 m^2 of HASLE Modular Lining in the hot zone.

The installation, carried out in early 2018, was remarkably quick. Each precast element was

HASLE Modular Lining during installation in 2018 in the hot zone of the cooler roof at a German cement plant. Thermal expansion joints are incorporated at every metre.

Finished installation of the HASLE Modular lining.

The same HASLE Modular Lining in the hot zone of the cooler roof in October 2023, five years after installation.

HASLE Modular Lining installation at Holcim Zementwerk Retznei, Austria. The adaptable anchoring system allows for a lining thickness as low as 185 mm. Looking to increase the cross-sectional area of the clinker cooler, it resulted in a gain of 420 mm in roof height compared to its previous solution.

40 m² HASLE Modular Lining being installed in the cooler roof at German cement plant in 2018.

The same HASLE Modular Lining after five years at a German cement plant.

securely fastened with a bolt and washer, smoothly sliding into a steel rail welded to the roof casing. The manageable weight of the precast elements further minimises installation time. Designed with tongue-and-groove joints on all four sides, the precast elements interlock and the joints are filled with 2 – 3 mm of mortar during installation. This approach minimises the penetration of gases into the insulation layer and anchoring system behind the elements.

After six months of operation, a detailed inspection of the lining showed no signs of wear. Given the excellent condition of the roof lining, the plant decided to install an additional 8 m^2 of HASLE's precast Modular Lining. This supplementary installation was successfully completed in February 2019.

The same Modular Lining has continued to operate seamlessly, now surpassing a five year lifespan without the need for any repairs. In a recent inspection conducted during a short shutdown in the summer of 2023, the precast roof lining was found to be in excellent condition and remains in service.

Customised lining

Through the flexible anchoring system, the lining thickness can easily be adjusted to suit individual operating conditions and heat-loss requirements. The Modular Lining precast elements serve as an efficient hot-face lining, allowing for a backup lining behind them. By employing an insulating castable with low thermal conductivity, the heat generated from the clinker cooling process can be recuperated, ensuring optimal heat retention within the process. Furthermore, achieving a lining thickness as low as 185 mm is feasible while still maintaining a high insulation capability – thus providing additional production space and consequently increasing production capacity.

Gaining room for extra throughput

The 1400 tpd cement plant in Retznei, Austria, which is part of Holcim and exclusively uses alternative fuels in normal operation, sought a new solution for the cooler roof. The objective was to increase the cross-sectional area of the clinker cooler, addressing bottleneck issues and optimising throughput. To achieve this goal, the plant's production

team sought guidance from HASLE Refractories. Their challenge was to decrease lining thickness while preserving a high insulation capacity and ensuring prolonged lining durability.

In March 2022, 20 m^2 of HASLE precast Modular Lining was installed on the roof in the hot section of the clinker cooler. This installation was complemented by HASLE D59A castable for the bullnose area.

With a lining thickness of 185 mm, "We gained 420 mm in roof height; I had calculated with 300 mm. Perfect!" exclaimed Sebastian Mervar, Production Coordinator at Holcim, Plant Retznei. This adjustment facilitated the smoother passage of materials through the area, effectively addressing the plant's operational challenges. An inspection in October 2022 showed that the roof lining was in good operational condition, much to the satisfaction of the plant production team. The lining continues to be in operation.

Further successes

The HASLE precast Modular Lining has also demonstrated excellent performance in clinker cooler applications at other plants. A German cement plant, operating at 5000 tpd and relying on 82 – 95% RDF, was looking for a more durable refractory lining due to challenges posed by abrasion and substantial alkali attack from high RDF use. In 2018, the plant installed 40 m^2 of HASLE's precast Modular Lining covering the entire cooler roof. Remarkably, after five years, there is no visible wear, and the lining continues to be in operation.

In Vietnam, a 5000 tpd cement plant operating on 70% coal and 30% alternative fuels (AF), was facing issues with short refractory life in the cooler bull nose area. The lifetime of the existing lining was no more than 8 – 12 months, meaning that the cement plant had to reline its cooler bull nose after each campaign. After installing a HASLE precast Modular Lining solution across the entire bull nose and hot zone cooler roof, they have now achieved a lining lifetime of four years.

Through a longer refractory lifespan as well as enhanced operational and thermal efficiency, cement plants can conserve natural resources and reduce maintenance costs, resulting in a more sustainable and efficient operation. ■

About the author

Henrik Andersen is Area Sales Manager for HASLE Refractories. Henrik holds a bachelor's degree in Export Trade and Technology and services for the Central and Northern European markets. Having a rich industrial experience spanning more than three decades, he has extensive theoretical and practical experience from on-site installations, and an in-depth understanding of refractory challenges and solutions.