Advancing refractories with cement-free gel-bonded gunite

The implementation of novel technologies in refractory materials, such as gel-bonded cement-free gunite, are transforming cement plant operations and cutting downtime. With new variations and the ongoing energy transition, that evolution looks set to continue.

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Refractories are indispensable in the cement industry, primarily in the higher temperature areas of the process, critical for clinker production. These heat-resistant materials line key components such as rotary kilns, preheaters and clinker coolers, withstanding extreme temperatures, thermal shock, exposure to chemical attack and abrasion. Given the demanding nature of the clinker manufacturing process, the performance and longevity of these refractories are crucial to protect equipment and operational efficiency.

In recent years technological advancements in refractory materials have led to more versatile, efficient and extended service-cycle solutions, resulting in cost savings and improved performance. Among these, a groundbreaking refractory system has gained significant attention for its versatility and performance in cement plants: gel-bonded cement-free refractory gunite. This article delves into the innovative gel-bonded cement-free gunite refractory system, its contributing property characteristics and how it is used with success in the cement industry.

Product evolution

Since the initial development of a 60 per cent alumina version of the gel-bonded cement-free gunite system in 2021, approximately 1100t of this version of the product have been put into service. Prior to this, a gel-bonded cement-free shotcrete had been supplied with very good success.

However, while gel-bonded shotcrete was a good solution, there was a clear need in the industry for reduced installation complexity. Using a similar technology to the shotcrete gel-bonded cement-free system, the gunite system was developed starting with an all-purpose 60 per cent alumina, cement-free product. Designed with ease-of-use in mind this product maintained excellent physical properties and incorporated accelerated dry-out capabilities.

The result was a product that had high alkali resistance, superior abrasion resistance, and excellent thermal stability with a service temperature limit of 1700˚C (3100˚F). This made it ideal for use in virtually any area of the clinkerisation process that can reach temperatures of 1450˚C (2645˚F) in a highly alkaline environment.

Figure 1: low dust emissions in a lower cyclone cement-free gunite repair

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Features and benefits

Installation and operational efficiency

The system allows for easy application using standard equipment and nozzle configurations. There is no need for the addition of complex additives (such as colloidal silica), reducing operational costs and set-up complexity. It is also easier to handle and apply in tight or difficult-to-reach areas, reducing installation time.

Low dusting and rebound

The system exhibits low rebound (10 per cent or less), adhering effectively to surfaces without much material loss. and resulting in a cleaner work environment and reduced material waste. This gel-bonded gunite does not require pre-dampening and has been designed to have installation characteristics comparable with low-rebound shotcrete. Despite being a gunite that does not require pre-dampening, it has a very low dust generation, as can be seen in Figure 1.

Veneering

The gel-bonded refractory system is a one-part formulation notable for its extreme stickiness and outstanding bond adhesion strength. These properties ensure that the material adheres effectively to both clean and pre-existing refractory substrates. This makes it an excellent choice for both veneering, where the refractory material is applied to existing surfaces, and applications which require full-depth design thickness. These excellent flashing and bond strength properties ensure that it can handle extreme temperature variations and thermal cycling without degrading or failing prematurely.

Abrasion resistance

The base system performs well in the abrasion resistance test (ASTM C704) with a typical result of 7-8cc loss or better. This ensures longevity in high-wear areas such as kiln hoods, coolers and ductwork (see Figure 2).

Figure 2: cement-free gunite repair in a tertiary air duct. Primary wear mechanism: high-velocity abrasion

Accelerated heat-up and reduced downtime

The absence of calcium aluminate hydrate phases enables, with high-temperature dehydration points, the use of a shorter dry-out schedule for gel-bonded gunite. The system's fast installation and drying times lead to less downtime, ensuring that plants can resume operations quickly without compromising performance.

Alkali resistance

One of the stand-out benefits of this gel-bonded cement-free system is its superior alkali resistance, outperforming low-cement gun mixes in environments exposed to alkali and other chemicals typically found in the cement manufacturing process. This reduces the risk of cracking and degradation due to chemical penetration in areas such as the tail ring (see Figure 3).

Extended shelf life and storage

One of the most significant advantages of the gel-bonded system is that it is cement free and does not require a colloidal silica liquid binder. Products based on the gel-bonded cement-free system react simply and conveniently with water at the discharge nozzle. Since it is not dependent on cement or a separate liquid binder, the gel-bonded system provides an extended shelf life compared with industry-standard alternatives. This makes the material easier for contractors, installers and cement manufacturers to store and use for emergency maintenance without the worry of significant waste due to ageing.

Proven experience

In the first cement outage season following the launch of this gel-bonded cement-free gunite product, it was selected for projects by multiple end users for a wide range of application areas. At a cement plant on the US East Coast, it was used successfully in a clinker cooler as the hot face of a dual component system with a lightweight back-up lining.

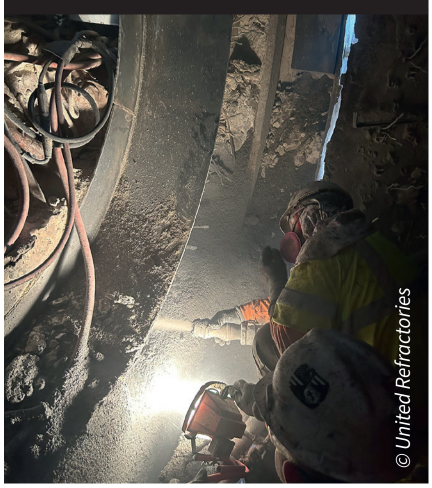
In another plant on the US West Coast, it was applied in the bottom of the stage five cyclone, lower calciner and kiln hood. The installation feedback was excellent and noted very low dust and high stickiness.

At another installation in the southeastern USA this product was selected specifically for veneering over a worn existing brick lining. The contractor for this project reported great adhesion to the brick surface, further proving the product's versatility. The results of these repairs out-performed traditional refractory materials and have since been the go-to maintenance product for these end users.

With the success of the 60 per cent gunite gel-bonded cement-free product under way, the platform was expanded to include other varieties tailored for service in other application areas of the cement manufacturing process. By adding zirconia or a combination of zirconia and silicon carbide to these products, property enhancements and an increased resistance to clinker build-up have been seen.

Further additions to the gel-bonded cement-free gunite portfolio were made in the form of a 70 per cent alumina version. Although the 60 per cent alumina version possesses good thermal shock resistance, the 70 per cent alumina version was developed to withstand conditions in areas where increased cycling is likely to occur. These types of conditions could be found in cooler drop zones, kiln hoods, tertiary air duct take-offs and burner pipes. In addition to the increased thermal shock resistance that this iteration was designed for, it also retained the high hot strength and abrasion resistance that the gel-bonded cement-free system naturally includes.

Figure 3: gunning a tail ring repair. Primary wear mechanism: aggressive alkali attack



Continuing to add to the repertoire of gel-bonded cement-free gunite products, 60 per cent and 70 per cent alumina versions were enhanced with added alkali resistance that did not involve the addition of zirconia or silicon carbide. The gel-bonded system has even been incorporated into a basic, magnesia-based gunite designed to adhere to existing magnesia brick in cement rotary kilns for quick and effective repairs.

Conclusion

Refractories are a crucial component of cement plant operations, playing a significant role in ensuring the efficiency, safety and longevity of high-temperature equipment. The introduction of advanced refractory systems, such as the gel-bonded cement-free gunite refractory portfolio, represents a major step forward in the evolution of refractories, offering improved performance, ease of installation and reduced downtime.

While the gel-bonded cement-free system was initially developed for cement plants, its applications extend beyond this industry. This platform has been successfully used in a variety of high-temperature industries, including lightweight aggregate production, lime production, waste incineration and biomass units. It has also been used in the foundry cupola furnace charge zone, showcasing its versatility and capacity to withstand the rigours of different high-heat environments.

Looking ahead, products based on this gel-bonded cement-free platform are an intriguing option for cement manufacturers to explore as the industry moves increasingly towards alternative fuels and carbon-neutral production. Refractory materials will continue to need to be modified to handle new types of fuels and alternative energy sources, such as solid recovered fuels, refuse-derived fuels, biofuels and hydrogen, which require refractories to operate at even higher temperatures and under more aggressive conditions. ■