REDEFINING REFRACTORIES

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Introduction

This article provides a short chronology of magnesia-based brick development, to quickly give refractory users an understanding of its advantages and disadvantages.

Magnesia-based brick

In the past, magnesia-based refractory brick was one of the most widely used basic refractory bricks in the rotary cement kiln's alkaline atmosphere, as it had outstanding chemical corrosion-resistance properties and high refractoriness. However, because of its high thermal expansion, which results in significant thermal stress between the hot face and the cold face of the brick, magnesia-based brick's thermal shock resistance was a major disadvantage. In unstable conditions, this could lead to a crack due to the uneven expansion rate between the cold face and hot face, which would eventually cause the installed brick lining to fall. The damage required the shutdown of the rotary kiln, so that the brick could be replaced, resulting in significant economic losses due to the loss of production and the cost of replacing the brick.

Magnesia-chrome brick

To solve this problem, magnesia-chrome brick was introduced. It had improved thermal shock resistance, as well as lower conductivity, higher flexibility, and higher strength at increased temperatures. The right chemical composition enabled magnesia-chrome brick to not only allow a quick formation of the coating on the lining, but also function as a coating stabiliser. Another advantage was its high resistance to hydration.

Despite these advantages, the use of magnesia-chrome-based materials in the alkaline atmosphere of the rotary kiln was limited due to environmental concerns: the thermo-chemical reaction of chrome and alkali generated a dissolvable hexavalent chrome compound (Cr^{6+}). Hexavalent chrome compounds (Cr^{6+}) are carcinogens and lead to environmental pollution, particularly when the waste chrome brick is incorrectly disposed of in

Table 1. Chronology of Siam Refractory's magnesia-based brick						
Generation	**Thermal shock resistance**	**Chemical resistance**	**Quick and stable coating formation**	**Hydration resistance**	**Environmental friendly**	**Cost***
Magnesia brick	*	*****	***	**	*****	Moderate
Magnesia-chrome brick	***	**	*****	****	*	Moderate
Magnesia-spinel brick	*****	****	****	**	*****	High
Ferro-magnesia-spinel brick	****	****	*****	***	*****	Moderate
* Depending on process and raw material cost.						

NEOMAG F in use in a cement kiln at SCG, Thailand.

NEOMAG F has a remaining thickness of 19 – 20 cm, from an original thickness of 23 cm.

municipal solid waste landfill. The hexavalent chrome can dissolve and pollute natural water reservoirs and natural underground water. The contaminated water is dangerous to humans and animals.

Magnesia-spinel brick

The Siam Refractory Industry developed magnesia-spinel bricks to prevent these environmental issues and to enable more advanced cement operation using alternative fuels (AF).

Cement manufacturers increasingly focused on plant utilisation and cost reduction, to maximise productivity with minimum costs. AFs are widely considered one of the most effective ways to achieve this target. However, using AF affects the kiln's operating conditions because of the difficulty in controlling their quality. As a result, the kiln's operation becomes more unpredictable.

Siam Refractory, a subsidiary refractory company of SCG Group, developed spinel technology that takes into account the adverse effects of using AF in the cement manufacturing process. Optimising the selection of raw materials and modifying the micro-structural design of the brick was the key to achieving the required thermo-chemical resistivity and reduced reactivity of the brick compounds.

Magnesia spinel brick became one of the most well-known bricks for use in severe conditions inside the rotary kiln when using alternative fuels. However, magnesia spinel bricks had two weaknesses:

1. The hydration reaction of magnesia-spinel brick was faster than that of magnesia-chrome brick, and most manufacturers determined that is had a shelf life of only 6 months.
2. The cost of magnesia-spinel brick was the highest of all magnesia bricks.

Ferro-magnesia-spinel brick with hybrid spinel technology

Siam Refractory then developed the new ferro-magnesia-spinel brick (NEOMAG F) by combining the advantages of magnesia-chrome brick and magnesia-spinel brick, to meet the specific requirements of various zones and to better fit with the most recent changes in cement manufacturing technology.

NEOMAG F was developed using the latest spinel technology, following a development concept defined as 'hybrid spinel technology'. The key developments included the selection of homogeneous raw materials and the right balance of additives, which gave the product the beneficial properties of both magnesia-chrome brick and magnesia-spinel brick.

Hybrid spinel technology allowed a significant improvement in retained strength value. The micro-cracks designed between the spinel and the periclase branches, protected against the thermal stress generated during thermal shock and helped to maintain the structure and strength of NEOMAG F.

The iron compound present in high iron magnesia is homogeneously distributed throughout the body. The coating adhesive test, along with the in-house rotary drum test, was used to observe coating corrosion and identify the products that occurred during the coating formation. The decomposition of high iron magnesia compounds reacts significantly with the calcium components from the kiln feed to form the ideal solid solutions or coating compounds that are firmly attached to the brick.

In the coating zones, the kiln feed becomes a liquid silicate component that infiltrates the refractory lining. NEOMAG F's coating can be applied quickly to form a thick, protective layer.

The optimisation of the coating compounds protects the refractory lining from unpredictable coating dislocations, which can happen from time to time in the cement kiln. Coating dislocation or 'coat shifting' occurs due to changes in the production parameters, such as a variation in the quality of the kiln feed and the quality or type of fuel.

Frequently, the coat shifting damages the refractory lining because the dense layer that is bonded between the refractory lining and the coating falls down when the temperature fluxtuates. NEOMAG F only allows optimal coating formation on its surface. Its structure is designed to minimise this falling down of the dense layer, which can reduce lining thickness and shorten the refractory lining's service life.

A special, in-house production technique is applied to create a specific matrix design using a thermo-chemical reaction during the firing process.

NEOMAG F also has good resistance to thermal load and high thermal shock resistance, meaning it can cope with the severe conditions and high thermal stress found in the coating zone.

Union Cement used NEOMAG F on its 10 000 tpd line because of these properties and then also at its central burning zone due to its previous good experience.

After 428 days in operation at a cement kiln in SCG Thailand, NEOMAG F still retains a stable coating with a remaining thickness of 19 – 20 cm (from an original thickness of 23 cm).

An anti-hydration treatment can be introduced as an additional process in the manufacturing of the bricks, and can be applied to any type of magnesia-based brick, including NEOMAG F. This helps to remove hydration risks, expired bricks, tangible and intangible losses, and premature failures of kiln brick lining.

Overall lining appearance of NEOMAG F after a 428 day running campaign.

Conclusion

In the cement industry, process optimisation, through various process improvements and guidelines, is being increasingly implemented to establish sustainable practices and competitive advantages.

Following this concept, the refractory industry continues to develop a series of products to serve specific needs. Hybrid refractory technology is one of these key developments, as it applies this optimisation concept, without compromising on quality and performance.