

INNOVATIVE SOLUTIONS FOR ROTARY CLINKER KILN REFRACTORY

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INTRODUCTION

The rotary kiln is the critical equipment in Portland cement clinker production. Nowadays, refractory materials used in these processing devices are Magnesia bricks due to chemical, mechanical and thermal requirements. The performance of refractory bricks is critical to the frequency and duration of maintenance shutdowns.

The shutdowns time is determined by the installation of the bricks, which involves several steps: removing coating, demolition of used bricks, kiln-ring assembling, bricking and kiln-ring disassembly. On the other hand, the schedule of the shutdown will be determined by residual thickness of brick lining. In order to assure the whole campaign, bricks are removed when thickness is lower than 40 % of the original one. Therefore, 60 % of material is removed, leading to important costs and increasing waste generation.

A promising alternative to overcome these disadvantages is the use of unshaped Magnesia based materials. The same applies for repair and maintenance as, rather than replacing cracked/worn bricks with new ones, the area can simply be sprayed with new material, making repairs quicker. This solution does not generate waste, reducing landfill charges, and therefore, involves cost and time savings as well as environmental, health and safety advantages. In addition, the option of relining up to the original brick thickness by gunning, increasing their lifespan becomes an excellent solution [1-3].

However, the major challenge for basic castables is the control of the hydration of magnesia, in order to prevent the spalling and cracking during the curing and drying steps. The hydration of MgO to brucite ($Mg(OH)_2$) implies a well know important volume expansion due to different densities, from 3.5 g/cm^3 of the oxide to 2.4 g/cm^3 of the corresponding hydroxide. If the hydroxide structure cannot be accommodated in the porosity of the castable, cracking phenomenon takes place. In the last decades, MgO castables have received a great attention and different routes have been investigated in order to minimize hydration, such as the addition of microsilica, the control of the pH, the nature of the magnesia and the use of anti-hydration additives [1-6].

The aim of this paper is the development of the Magnesia-Spinel castables as an innovative alternative and/or complement to MgO lining bricks in rotary clinker kilns. The design allows the application of the castable by gunning and casting, in order to have a versatile product range that satisfies all the needs of the clinker producers.

DEVELOPMENT

As first stage, different magnesia sources and anti-hydration additives were studied.

The control of the Magnesia hydration in water based castables has been carried out by two different ways, the selection of raw materials (magnesia source, microsilica and the addition of additives) and the design of the microstructure.

Through the design of Magnesia- Spinel castable has been achieved:

- The control of the brucite formation.

The presence of brucite increases the risk of cracks formation. In the worst scenery the spalling during curing time, due to volume expansion, could happen. Moreover, the risk of spalling is still present during heat treatment (dehydration of brucite).

Hydration of basic castable was studied by macro thermogravimetric analysis (TGA) system. The evolution of weight loss versus temperature shows an important loss of 4% at temperatures lower than 200°C (Fig. 1). From 200°C to 600°C a progressive reduction of weight loss takes place. No significant weight loss is detected around 400°C where dehydration of brucite occurs [5]. Taking that into account the formation of brucite takes place in low quantities, so the microstructure developed is able to eliminate dehydration vapors without any damage in the castable.

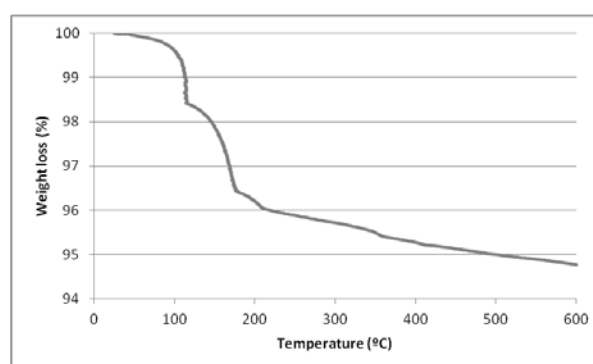


Fig. 1: Evolution of weight loss versus temperature measured by macro TGA.

- Compatibility with the substrate (Magnesia-Spinel bricks)

Other critical point that determines the viability of basic castable as solution is the compatibility between the substrate, bricks, and the new material coating, Magnesia-Spinel castable.

Compatibility has to be adequate in the working temperature range to assure the success of basic coating solution.

A Magnesia-Spinel castable has been sprayed over some commercial bricks that were recovered after being used. Then, the interface has been studied by field-emission scanning electron microscopy (FE-SEM) after different temperatures treatments. In the following figures, 2 and 3, the microstructure of interface, brick and castable contact area, can be seen. As it can be observed, there is a very good integration and adherence, without thermomechanical stresses. No hydration of magnesia bricks is observable as confirmed by X-ray powder diffraction (XRD).

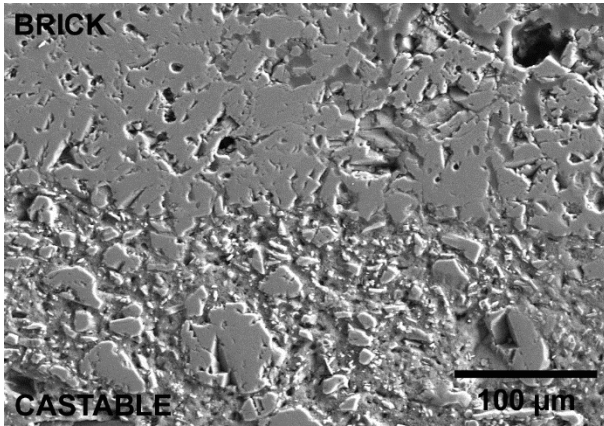


Fig. 2: FE-SEM microstructure of the interface area between basic castable and brick treated at 1500°C/5h.

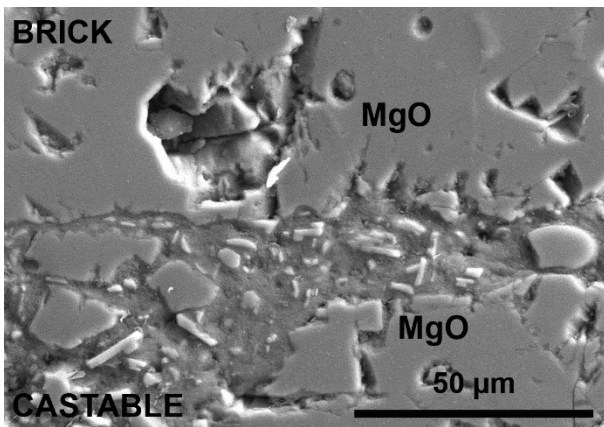


Fig. 3: FE-SEM microstructure of the interface area between basic castable and brick treated at 1500°C/5h.

FIELD TRIALS

To date, several field trials have been carried out in different cement plants (Tab. 1). In all cases, complete rings were made in order to assure the self-supporting of the basic castable. No metallic anchors were used. Basic castables were installed by gunning.

The main challengers that castable have to overcome are:

- Standard heating up curve should be secure for castable dry-out.
- Castable must have enough mechanical strength during initial kiln rotation throughout start-up, when temperatures are lower and bonding between particles is feeble because reaction sintering has not started yet.

- Castable must resist initial feeding impact, when stable coating is not protecting the lining.
- Castable must develop good adherence with residual bricks, from ambient to process temperature.
- Castable must be capable to form stable clinker coating.
- Castable must have refractoriness as high as regular bricks
- and have good enough resistance against corrosion

Tab. 1: Main characteristics of some field trials.

Cement Plant	Capacity (tons/day)	Length (mm)	Castable Thickness (mm)	Area	Operation time (days)
CPV (Alfa Mataporquera, Spain)	2000	1000	60	Stable Coating	52
INTERCEMENT (Alhandra, Spain)	4900	2600	58	Stable Coating	150
CEMEX (Castillejo, Spain)	4100	1000 1000	35 60	Lower Transition	5

The behaviour of the basic castable during start-up was appropriate. Neither peel-off has been detected in the first stages nor during clinker feeding, where the material has to support rotational stresses at low temperatures.

As it is well known, one of the thermo-mechanical lining parameters of huge importance for durable lining is the formation of stable coating on the refractory surface. Formation of the clinker coating was validated by thermal scanning. At process conditions, the external temperature registered in the coated zone was 20 degrees lower than in similar areas (Fig. 4).

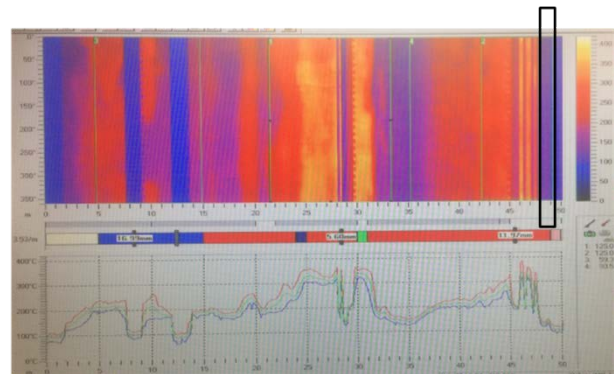


Fig. 4: Thermal scanning at 15 days. Castable lining area is pointed.

At InterCement Alhandra, the largest trial area was installed, with a total length of 2.6 meters (Fig. 5). Bricks were gunned in order to achieve the same thickness as new bricks. No problems were detected during start-up, and formation of the clinker coating was similar in all stable coating area of the kiln. During the first 48 hours the clinker was chemical analyzed each hour

and no alteration have been detected. As in the previous case, castable have enough mechanical strength at early temperatures and good adherence with bricks.

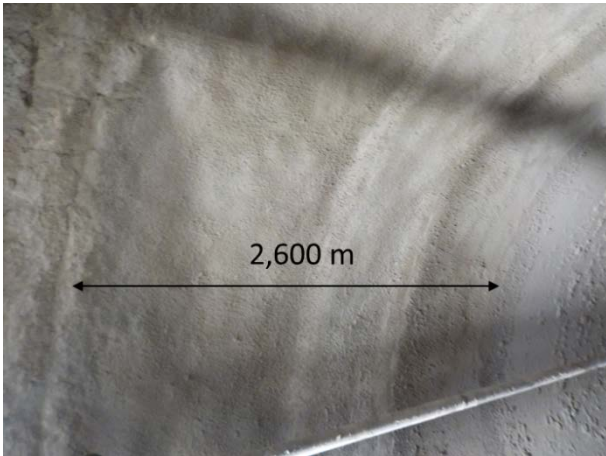


Fig. 5: Final appearance of the castable lining area. INTERCEMENT Alhandra, Portugal.

Temperatures registered during the 5 months of operation were similar to historical new bricks lining data (see Fig. 6). After 5 months the clinker layer was demolished. Basic castable layer was removed with the clinker coating. It is important to stand out that brick's substrate does not have any wearing while adjacent bricks have suffered a wear of 20-30mm.

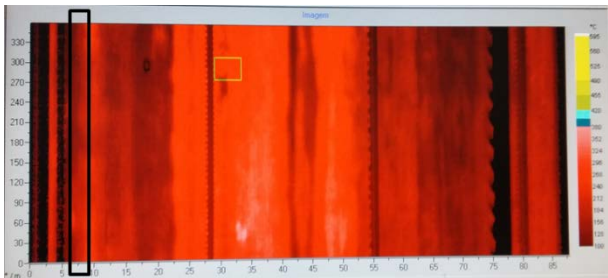


Fig. 6: Thermal scanning at 145 days. Castable area is pointed.

At CEMEX plant were installed two different areas, with a length of 1 meter each, in the lower transition area (Fig. 7). Operation time took place without any incidence. After 5 days of operation the appearance of the castable was excellent, without material losses, cracks or any other potential problems (Fig. 8). An analysis of a piece of the basic castable coated shows a good refractoriness of the material and no corrosion (Fig. 9).



Fig. 7: Pictures of the bricks lining before castable application and the final appearance of the coated area, CEMEX Castillejo, Spain.



Fig. 8: Magnesia-Spinel castable coating after 5 days of operation. CEMEX Castillejo, Spain.



Fig. 9: Cross section of Magnesia-Spinel castable after 5 day of operation.

CONCLUSIONS

An innovative alternative for rotary Clinker kilns lining has been developed with promising results.

The first trials demonstrate the proper behavior of the Magnesia-Spinel castable developed.

Rebuilt of the used bricks with the Magnesia-Spinel castables offers an excellent solution, as no-ending concept, promoting reductions in time and costs on maintenance shutdown together with significant environmental, health and safety advantages.

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