Magnesia-Spinel Castable. An Innovative Solution for Clinker Kilns

By: M. Alvarez, V. Alvarez, O. Burgos-Montes, I. Recio
Refractarios Alfran, SPAIN

INTRODUCTION

Nowadays the use of basic bricks in the rotary clinker kiln determines the maintenance shutdowns in terms of frecuency and duration. The requirements of refractory materials for the burning zone in clinker rotary kilns are different from the other areas in cement production. The combination of high temperatures, chemical conditions and mechanical stresses leads to the employment of Magnesia based bricks. Disadvantages of shaped to unshaped materials are well-known. Shaped materials have been progressively substituted by unshaped materials in other areas such as kiln hood or cooler.

A promising alternative to overcome these disadvantages is the use of unshaped magnesia materials. ALFRAN innovative solution involves an important cost and time saving. Moreover the substitution of the bricks leads to environmental, health and safety advantages [13-].

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 [16-].

The aim of this paper is the development of the Magnesia-Spinel castables. ALFRANMAG 85 HG is a basic castable, and gives an innovative alternative and/or complement to MgO bricks in rotary clinker kilns. The application of this castable can be performed by gunning or casting, in order to have a versatile product range that satisfies all the needs of the clinker producers.

DEVELOPMENT

As first stage, in lab scale, the study was focus on the control of the Brucite formation and therefore the cracks formation.

The control of the Magnesia hydration in water based castables was 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 formation of Brucite without control increases the risk of cracks formation or explosions during the curing time and during the dried out (dehydration of Brucite).

Hydration of basic castable was studied by macro-thermogravimetric analysis (TGA) system. In figure 1 can be seen the behavior of the designed castable with the selected Magnesia source and the proper additives. The evolution of weight loss versus temperature shows an important loss of 4% at temperatures lower than 200ºC. From 200ºC to 600ºC a progressive reduction of weight loss takes place. No significant weight loss is detected around 400ºC 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 accommodate the Brucite in the structure and eliminate dehydration vapors without any damage in the castable.

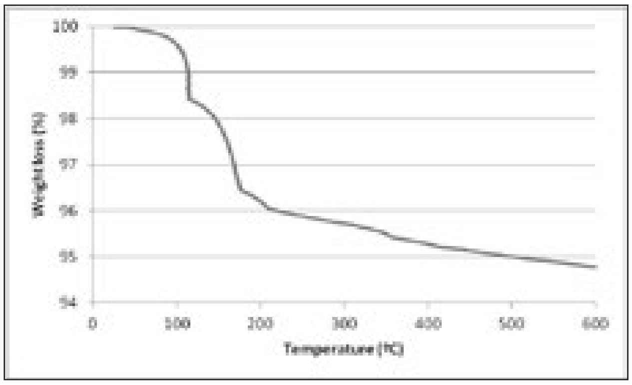

Fig. 1: Evolution of weight loss versus temperature measured by macro TGA.

- 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, old-bricks, and the new material, Magnesia-Spinel castable. Compatibility has to be adequate in all the temperature range to assure the success of basic coating solution.

A Magnesia-Spinel castable was sprayed over some commercial bricks that were recovered after being used. Then, the interface has been by different techniques after different temperatures treatments. In the following figure 2, 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).

FIELD TRIALS

To date, several field trials have been carried out in different cement plants in Europe and America. In all cases, complete rings were made by gunning in order to assure the self-supporting of the basic castable. The area coated was the stable coating area. No metallic anchors were needed (Fig. 3) and an important reduction in shutdown time was obtained (Fig.4).

Fig. 3: Aspect of the ALFRAN castable installed.

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

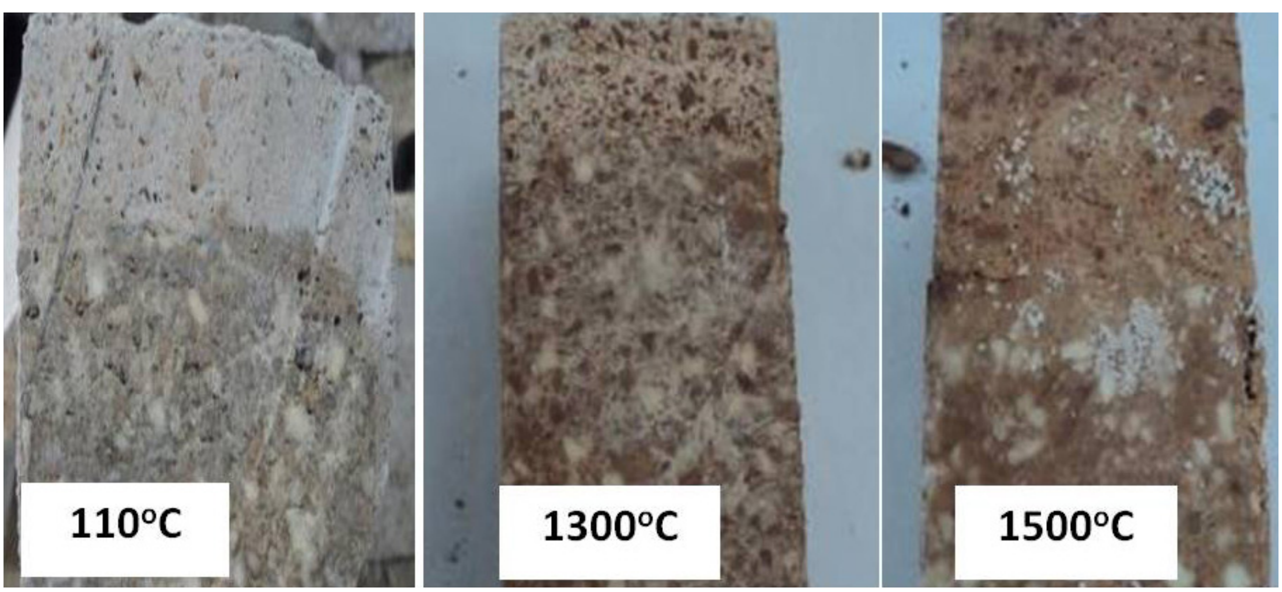

Fig. 2: Pictures of the interface area between basic castable and brick treated at 110ºC, 1300ºC and 1500ºC/5h.

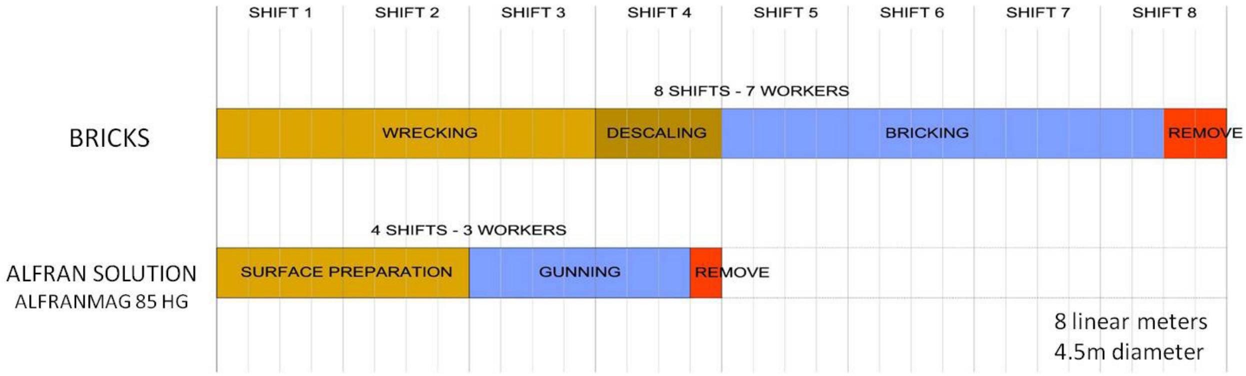

Fig. 4: Schedule of comparative shutdown (Bricks or Castable installation)

between particles is feeble because reaction sintering has not started yet.

- Castable must resists 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.

The behaviour of the basic castable during resume 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. No magnesia increment in the chemical analysis performed by the cement plants was detected on these first stages.

As it is well knew, one of thermo-mechanical lining parameter 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 in all the cases. No differences were detected between coated areas and new bricks areas. At process conditions, the external temperature registered in the coated zone was lower than adjacent similar areas (Fig.5 and Fig.6).

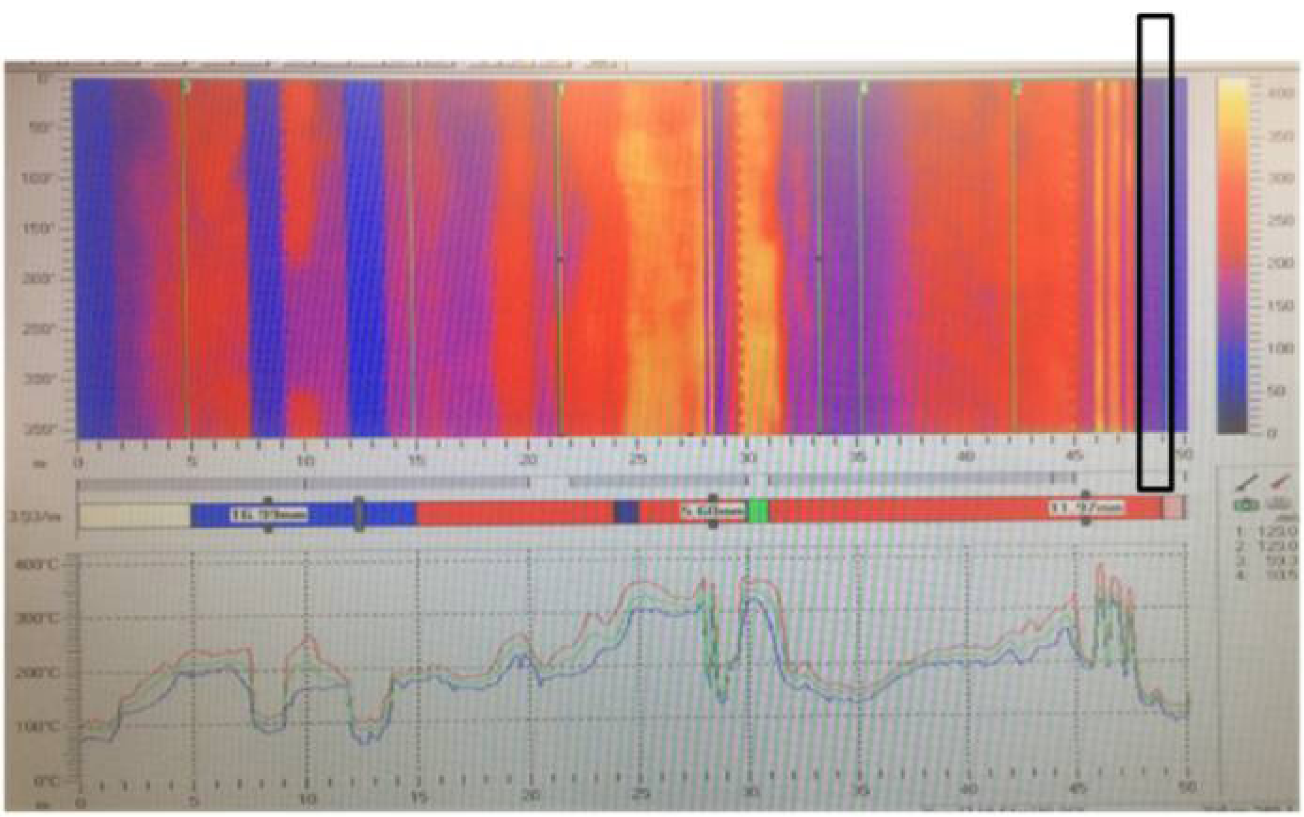

Fig. 5: Thermal scanning at 15 days. Castable lining area is pointed.

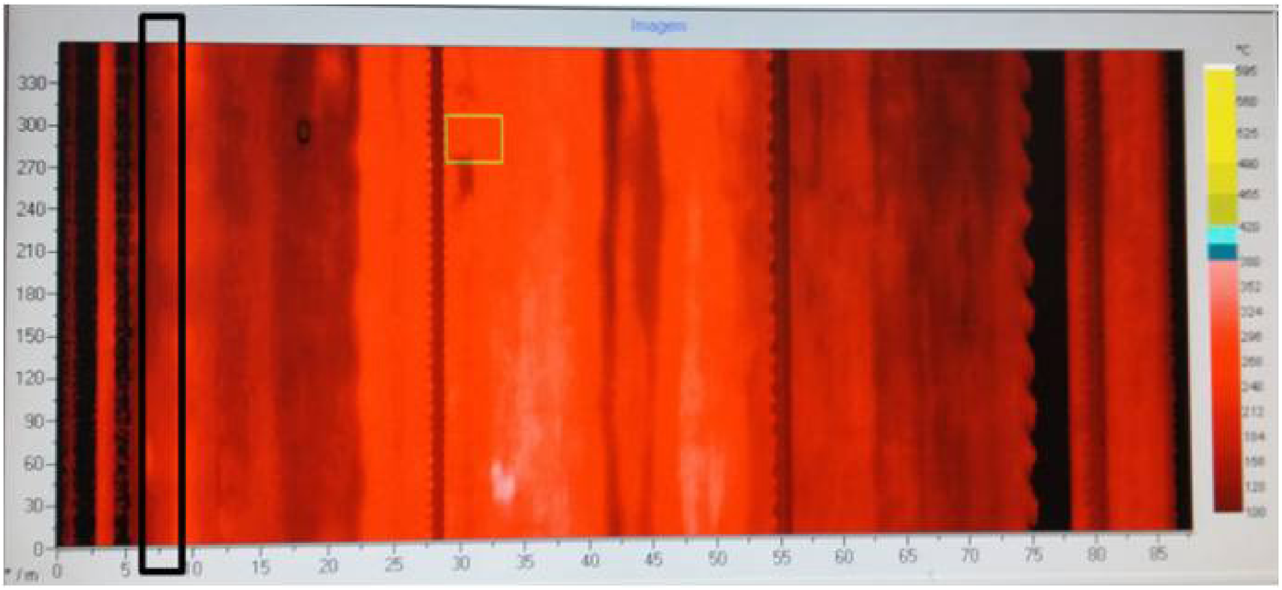

Fig. 6: Thermal scanning at 145 days. Castable area is pointed.

After the service, during the shutdown 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 habitual wear. So the presence of the castable has avoided the wearing of the bricks.

The post-mortem analysis of the castable shows good properties, good refractoriness and the expected corrosion by clinker layer (Fig. 7). The clinker corrosion on the castable layer was similar to the regular Magnesia-Spinel bricks.

CONCLUSIONS

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

The first trials demonstrate the proper behavior of the Magnesia-Spinel castable developed, ALFRANMAG 85 HG.

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.

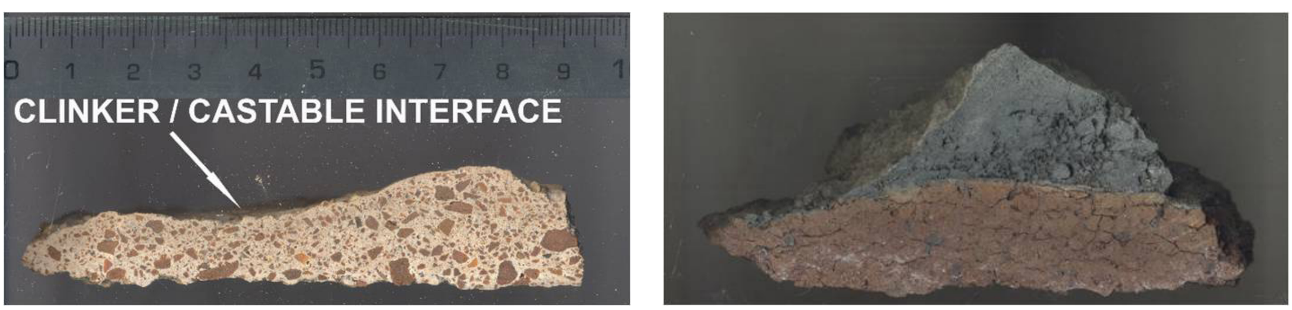

Fig. 7: Cross section of Magnesia-Spinel castable after the service.

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