# In the **Line of Fire** >>>>

*Herbert Hönl, Refko Feuerfest, Germany, Belen Caballero and Eduardo Diez del Sel, Reyma Materiales Refractarios, Spain,* *discuss monolithic material and lining solutions for cement plants with a high mechanical and chemical stress caused by increasing amounts of secondary and/or alternative fuels.*

Recently the widespread use of alternative fuels in cement production has forced many plants to reconsider their refractory lining concepts. The increasing amount of these secondary/alternative fuels leads to significant chemical and mechanical problems within the traditional refractory linings. The authors' companies have developed a new range of products and lining concepts to tackle this modern complication. These have been designed to withstand the severe conditions taking place in the refractory lining, specifically in terms of chemical attack, thermal shock and mechanical stress.

## Development

Firstly, a monolithic refractory material that can withstand the problems outlined above was developed. This led to the ZSI product series, which was placed on the market in 2003.


Figure 1. Alkali bursting test (5 h at 1100 ˚C with $K_2CO_3$)

During the burning of secondary fuels, a high amount of aggressive gases are produced (e.g. alkaline, chloride, sulfates etc.). These gases have a negative influence on the performance of refractory materials. They penetrate into the refractory and create an area of attack; specifically the alkali reacts with the aluminium-silicates to form an alkali-aluminium-silicate of low density and higher volume than the original minerals. This leads to 'alkali bursting', an extreme expansion phase causing the destruction of the monolithic lining.

Normally, these chemical problems could be overcome through the use of high amounts of SiC in the refractory lining. In the past this technique has worked very well and there were many products available on the market with over 40% SiC content.

However, the problem with high SiC containing refractories is their relatively limited lifetime. The reason for this is found in the secondary fuels and other raw materials used. More and more cement plants inject fluid secondary raw materials, for example bio-solids. This results in the formation of a kiln atmosphere with an alternating amount of steam, which can lead to the passive oxidation of the SiC inside the refractory materials, as shown in the equation below:

$$SiC\ (s) + 2\ H_2O\ (g) \rightarrow SiO_2\ (s) + CH_4\ (g)$$

In this case, the refractory will also be destroyed by the expansion of the newly formed $SiO_2$.

To overcome this specific wear mechanism, the SiC content is less than 10% in the ZSI materials. Moreover, this content is located in a dense matrix to protect the SiC. The high density of these refractory materials also hinders the ability of the corrosive gases to penetrate the refractory, again resulting in enhanced lifetimes.

## Alkali bursting test

The alkali bursting of an unprotected standard product is clearly visible in Figure 1. The classic materials with 60% SiC (660 SIC) show an infiltration, but no alkali bursting. Only the ZSI products show no infiltration.

Although the laboratory crucible tests are not entirely representative of what happens on an industrial scale, the performance of the ZSI product series in many varied practical experiences is a testament to its future development.

In addition to the direct chemical influence of the secondary and/or alternative fuels to the refractory material, there are other problems to face. The use of these fuels also has an effect on the whole kiln burning system and often leads to unwanted deposits and build-ups, which have to be crushed down with different cleaning methods (e.g. air cannons, water cannons, Cardox etc.). This results in a high mechanical stress on the refractory lining. Cleaning with water also causes additional thermo-mechanical stress for the refractory. Therefore it must have an excellent resistance against abrasion, mechanical and thermo-mechanical stress. The use of raw materials containing Zirconia addresses this problem.

## New anchor system

It would be too easy if all the refractory lining problems caused by the secondary and alternative fuels could be solved with state-of-the-art refractory material alone. However, the

**Table 1. The ZSI product series**

| | $Al_2O_3$ (%) | $SiO_2$ (%) | (%) | AT (˚C) | CCS 1450 ˚C (N/mm²) | (t/m³) |
|---|---|---|---|---|---|---|
| Supergun 63 ZSI<br>Gunti xGX-663 ZSI | 63 | 10 | 11 ($ZrO_2$), 7 (SiC) | 1450 | 100 | 2.7 |
| Refcast V663 ZSI<br>Reotix RX-663 ZSI | 63 | 12 | 12 ($ZrO_2$), 7 (SiC) | 1500 | 150 | 3.0 |
| Ispocast 63 ZSI<br>Reotix RX-63 ZSI AC | 63 | 10 | 12 ($ZrO_2$), 7 (SiC) | 1450 | 100 (800 ˚C) | 2.9 |
| Ispocast 63 ZSI-K<br>Reotix RX-667 KZSI | 63 | 10 | 13 ($ZrO_2$), 7 (SiC) | 1550 | 100 | 2.9 |
| Vibrolit 63 ZSI<br>Reotix RX-663 ZSI S-L | 63 | 13 | 13 ($ZrO_2$), 6 (SiC) | 1450 | >110 (1250 ˚C) | 2.9 |
| Cast Gun 663 ZSI<br>Procast PR-663 ZSI | 60 | 15 | 12 ($ZrO_2$), 7 (SiC) | 1480 | 100 | 2.9 |

Figure 2. Refko Seal Anchor System.

corrosion of the metallic anchors is another of the great challenges needing to be solved.

Depending on the due points of the corrosive gases, the condensation at the metallic anchors leads to massive corrosion. Due to the high density of the ZSI products, the amount of gases that reach the anchors can be reduced.

For very hard corrosive conditions, as an additional solution, the Refko Seal Anchor System was developed (Figure 2). The metallic anchor is protected in an inner ceramic ZSI core with special coating and heat treatment. This is then stored in an almost gas-tight ceramic ZSI body, allowing no corrosive gases to reach the metallic anchor. There is no condensation and corrosion to the metallic anchor, as an additional layer of castable protects the inner core.

The ZSI product series used in combination with the Seal Anchor System offers a state-of-the-art refractory lining to solve the problems caused by the use of secondary and alternative fuels.

## Outlook

It is clear that the modern supplier of refractory material must not only look for new refractory materials but for total solutions that will affect the whole lining process (material, engineering, installation, etc.).

At the moment there are positive field tests in place, with an advanced grating system to further minimise problems caused by abrasion. The company also expects that pre-shaped block solutions will find wider use in the future.

Together with partners such as Jünger+Gräter GmbH, projects such as a monolithic rear ventilated lining system – to inhibit anchor corrosion combined with better thermal insulation of the casing – are being developed. The system with the branding JuSyS® ACL is a technology transfer of the well known used lining concept in the waste incineration industry.

Additionally, efforts are being made to reduce the installation and shut down time by the following actions:

- Installing semi-insulating materials for single-layer wall lining.
- Installing complete walls without forming fields and joints, with SOL-GEL technology.

Refko Feuerfest GmbH and Reyma Materiales Refractarios, S.A, aim to continue to pursue new solutions for refractory in an increasingly challenging environment.