

# Ring the changes

by Gilles Mercier, and  
David A Jarvis,  
Wahl Refractory Solutions,  
USA

Refractories that are designed for the kiln nose ring endure some of the most intense and persistent wear from various types of chemical attack and physical processes. However, Wahl Refractory Solutions' SIFCA™ technology – a reinforced refractory concrete for the production of precast shapes – has been successfully installed in hundreds of cement kiln nose rings worldwide. The latest SIFCA composite nose ring installation at Ash Grove's Durkee plant, USA, has seen an unprecedented length of service.

At elevated temperatures, Wahl Refractory Solutions' Slurry Infiltrated Fiber Castable (SIFCA™) precast shapes replace conventional refractory, cast iron and stainless steel parts with extreme resistance to thermal shock, mechanical abrasion and high impact wear.

The first application of SIFCA in the cement industry were precast refractory beams for introducing tyres as fuel into the preheater system at the UK-based Dunbar cement works (formerly Blue Circle, now CRH Group) in the late 1980s. The weight of the tyres, the temperature and the thermal shock combined to create conditions where conventional steel and refractory beams failed rapidly within a few days. The SIFCA solution led to a 50-fold increase in life.

## Development of nose blocks

Following early successes, new applications for SIFCA precast shapes were investigated, leading to the development of SIFCA nose blocks as an alternative to conventional refractory castable nose rings. Conventional nose ring design combines a castable refractory anchored to an alloy nose casting bolted through

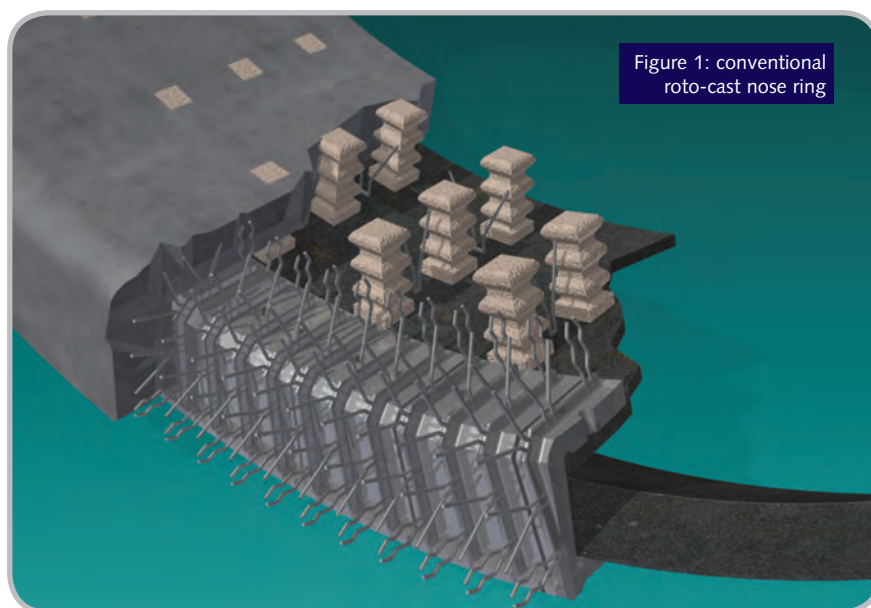


Figure 1: conventional roto-cast nose ring

the kiln shell (see Figure 1). Wahl's precast SIFCA refractory composite nose blocks are engineered to replace both alloy nose castings and their refractory lining.

For each kiln, Wahl engineers develop a custom-made nose block design which addresses the geometry and operational parameters of that nose ring. Figure 2 shows the typical design for a SIFCA nose block which bolts directly to the kiln shell,

utilising the same bolt pattern as the existing alloy nose castings.

## Installation

The installation of a SIFCA nose ring is shown in Figure 3. Installation times are greatly reduced with each block placed and bolted into place in about 30 minutes. This compares favourably with conventional roto-cast nose rings which

Figure 2: SIFCA precast nose block design

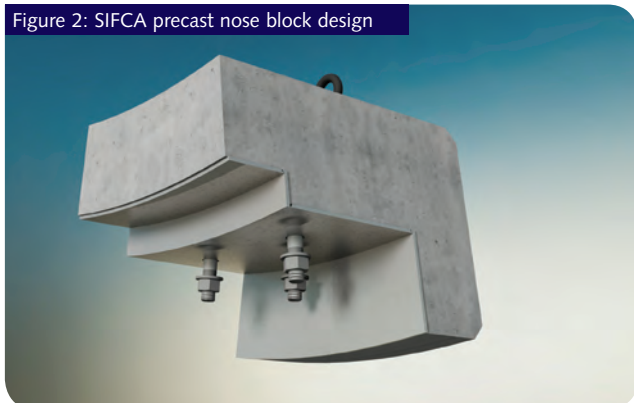


Figure 3: SIFCA nose ring installation



**Table 1: labour\* (24-month life cycle)**

	<i>Conventional castable nose ring labour (man hours)</i>	<i>SIFCA™ nose ring labour (man hours)</i>
Nose ring tear-out	48	48
Castings removal	48	48
Castings install	96	-
Install retaining ring	192	192
Anchor install	96	-
Forming castable	96	-
Nose ring installation	60	300
Pulling forms	12	-
<b>Subtotal Year 1</b>	<b>648</b>	<b>588</b>
Nose ring tear-out	48	-
Castings removal	-	-
Castings install	-	-
Install retaining ring	-	-
Anchor install	96	-
Forming castable	96	-
Nose ring installation	60	-
Pulling forms	12	-
<b>Subtotal Year 2</b>	<b>312</b>	<b>0</b>
<b>Total (Year 1+2)</b>	<b>960</b>	<b>588</b>
<b>Labour reduction</b>		<b>-372</b>

\*For the labour estimations, the assumption was two 12-hour shift/day and 2-5 labourers/shift depending on the activity

require the installation of nose castings, welding of anchors, forms preparation, castable mixing and pouring, curing and forms removal prior to a specified dry-out schedule with hold periods at several temperature thresholds.

Table 1 compares installation times over a 24-month life cycle for SIFCA nose blocks and a conventional refractory castable nose ring. For this comparison, both options begin with the removal of a conventional castable nose ring. A typical roto-cast nose ring was used, with the castable replaced every year, and alloy castings and retaining ring replaced every two years.

Table 2 calculates the estimated kiln downtime associated with the nose ring installation. During annual maintenance kiln stops, cement kilns are typically shut down for 14 days or more, so the installation of a nose ring will not cause any additional kiln downtime. The installation of SIFCA nose blocks can easily accommodate kiln turns necessary for other maintenance, such as shimming or replacing kiln tyre pads. Conversely, roto-casting a conventional castable nose ring requires dedicated kiln rotations until shell preparation, anchors, forming and pouring is complete, thereby delaying other important kiln maintenance. In the event of a kiln stoppage, caused by a nose ring failure, the downtime associated with conventional nose ring replacement will be 10-12 days including curing and dry-out time.

SIFCA nose blocks will give a typical nose ring life of two to three years. The nose ring replacement can be scheduled during annual kiln maintenance stops, thereby eliminating mid-year unscheduled kiln stops and production loss due to nose ring maintenance.

**Table 2: kiln downtime associated with nose ring installation**

	<i>Conventional castable nose ring downtime (h)</i>	<i>SIFCA™ nose ring downtime (h)</i>
Installation time	162	132
Curing	24	-
Dry-out	72	-
<b>Subtotal Year 1</b>	<b>258</b>	<b>132</b>
Installation time	78	-
Curing	24	-
Dry-out	72	-
<b>Subtotal Year 2</b>	<b>174</b>	
<b>Total (Year 1+2)</b>	<b>432</b>	<b>132</b>
<b>Downtime reduction</b>		<b>-300 (12.5 days)</b>

## SIFCA nose ring development

The first complete SIFCA nose ring was installed in the late 1980s and operated for one campaign. The cement producer had been experiencing severe problems with high refractory wear rates, giving lives of only a matter of weeks in some cases with their conventional refractory castable nose rings.

After this successful trial, a second set of nose blocks was installed with a slightly thicker section and based on a silicon carbide grade of SIFCA. After two years in service, the maximum wear on the SIFCA block was about 25mm while

the adjacent brick showed more than 100mm of wear after a throughput of about 1.5Mt of clinker.

Following 30 years of experience in varying kiln conditions, the newest generation of SIFCA refractory composite has been optimised to a matrix composed of high-purity silicon carbide and mullite additions, and a high 16 per cent volume of stainless steel fibres offering oxidation resistance at elevated temperatures.

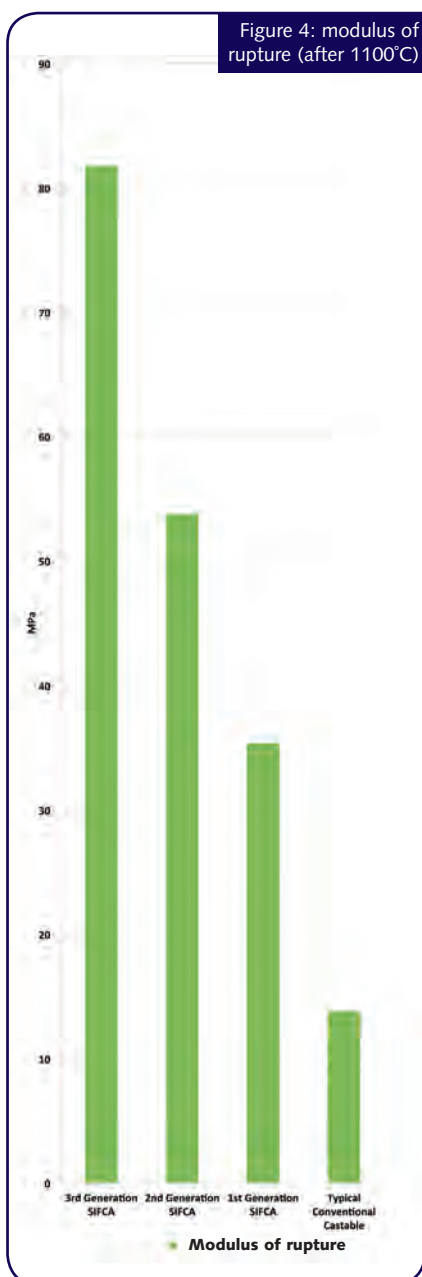
The chemical composition of the refractory matrix (see Table 3) was optimised for resistance to alkali salt attacks, and resistance to clinker liquid phase attack.

**Table 3: typical chemical analysis of refractory matrix**

	SiC	Al <sub>2</sub> O <sub>3</sub>	SiO <sub>2</sub>	Other
Third-generation SIFCA chemical composition (%)	58	24	14	4

### Comparison: SIFCA and conventional castables

In Figure 4 the flexural strength of a typical low-cement refractory castable commonly used in nose rings today is compared with SIFCA. The original SIFCA refractory composite had more than double the strength of the roto-cast refractory. The second generation of

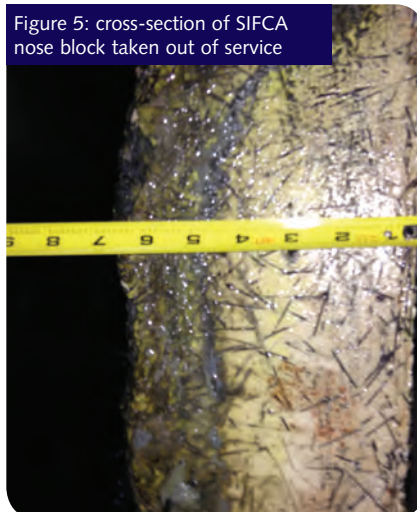


SIFCA resulted in more than a three-fold increase in strength, and the latest generation of SIFCA composites have six times more flexural strength in comparison to the conventional low-cement castable.

In addition to high flexural strength, which allows the latest generation SIFCA to resist the dynamic mechanical stresses applied to the nose of the kiln, SIFCA also offers unsurpassed resistance to impacts and thermal shock. This combination of physical properties results in unsurpassed resistance to spalling from mechanical forces and densification due to alkali salt or clinker liquid phase infiltration. Figure 5 shows the cross-section of a SIFCA nose block taken out of service, exhibiting 50-75mm of clinker liquid phase infiltration but no evidence of cracking or spalling seen in other types of refractory under these conditions.

In cement kiln nose rings, the temperature on the hot face cycles in each revolution from about 1350°C down to perhaps 1150°C as the nose ring rotates through the clinker bed and is then exposed to secondary air from the cooler. With its resistance to thermal shock, the net effect is that SIFCA maintains its mechanical properties even when exposed to thermal cycling at

Figure 5: cross-section of SIFCA nose block taken out of service



these elevated temperatures, minimising refractory wear and maximising service life.

### Ash Grove case study

It was news of such high performance of SIFCA refractories that came to the attention of Ash Grove Cement's Durkee cement plant, in the northwestern state of Oregon. Plant operators had been finding that the nose ring refractories needed replacement every year, and looked for a solution to provide multi-year campaigns.

The plant is one of eight integrated cement works that Ash Grove operates in USA with a combined capacity of 7.8Mta. The Durkee plant started production in 1979, and underwent a 1998 capacity expansion to the current 0.9Mta. It has one  $\phi$ 4.3m kiln with a four-stage preheater and separate-line calciner. The main kiln burner fuel is a combination of coal and natural gas, while tyre-derived fuel is also burned in the preheater tower.

## Advantages

SIFCA nose blocks are shipped ready to be installed, and require no additional curing or dry-out schedule. They can be heated up to kiln operating temperature at the same rate as the brick in the adjacent burning zone.

### Advantages of SIFCA nose rings

- increased nose ring performance in comparison to conventional refractory castable
- reliable engineered design results in predictable life without premature failure
- installation time and cost is greatly reduced compared to a roto-cast refractory nose ring
- no need for dry-out procedure, reducing downtime
- reduced total life-cycle costs over multi-year campaigns.

Figure 6: SIFCA nose blocks in a  $\phi$ 4.3m precalciner kiln producing 3200tpd of clinker, after one year of service



In February 2013 the decision was made to upgrade to Wahl's newest third-generation SIFCA composite nose blocks. One year later in March 2014 the nose blocks were inspected to reveal very little wear (see Figure 6) judging by the adjacent brick which had been replaced three months earlier.

In January 2015 during the plant's winter kiln outage, the SIFCA blocks were inspected at the 22-month mark (see Figure 7) and remnant thickness was estimated to range 190mm-215mm, resulting in an average wear of approximately 25mm. The decision was made to leave the SIFCA blocks in service at the works for a third year. At the 28-month mark the blocks are holding strong and should complete three years of service.

#### Extended service life

The majority of SIFCA nose rings in service today perform for two to three



Figure 7: SIFCA nose blocks after two years in service

*The decision was made to leave the SIFCA blocks in service at the works for a third year. At the 28 month mark the blocks are holding strong and should complete three years of service.*

years operation, with the latest generation of SIFCA refractory composites performing reliably for three years in service. Some SIFCA nose blocks have given up to four years of life in  $\phi$ 4.5m kilns. In a 6m precalciner kiln producing 12,000tpd clinker, SIFCA nose blocks recently performed for 600 days, showing an average remnant thickness of 175mm after 5.6Mta of clinker produced.

#### Setting SIFCA apart

The key characteristics of SIFCA are its thermal shock resistance, impact resistance, flexural strength and refractoriness when compared to conventional refractory solutions, all of which explain the success in extending the life of cement kiln nose rings.

The properties of SIFCA rapidly gave rise to its use in other critical applications, which were proving too arduous for metal alloys, refractory brick or other monolithics installed in place. These applications have included tertiary air duct dampers, cooler roof bull noses and blasters nozzles in the cooler and in the preheater areas. There have also been installations in cooler roof and sidewall precast block construction, sight hole ports, mid-kiln tyre chutes, kiln tail rings and feed tray applications. █



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