LONG-LIFE LININGS

Alexia Yiakoumi, Höganäs Bjuf Middle East, describes two case studies where plants have achieved remarkably long life by utilising appropriate refractory bricks.

Introduction

Höganäs Bjuf has developed the Alsic 500 brick to satisfy customer's needs and to remedy costly problems. Alsic 500 was first produced in 2006 and launched to the market as a solution for areas exposed mainly to alkali attack, refractory spalling, buildup and abrasion problems. It has already proven to be a superior product, with unique physical and chemical properties and a long lifetime – achieving as much as three years in riser ducts.

Alsic 500 is an alkali-resistant fire brick based on fireclay boosted with bauxite and silicon carbide. Its physical properties include:

- Low density (2.35 g/cm^3) with high porosity (19%).

Figure 1. Microphotograph of Alsic 500 brick.

- The refractoriness under load T05 is equal to 1350 °C and T5 equals 1480 °C.
- Thermal conductivity at 500 °C is 2.0 W/mK and reaches 3.5 W/mK at 1250 °C.
- Important chemical properties are 50% Al_2O_3, 1.4% TiO_2, 37% SiO_2, 1.3% Fe_2O_3 and 9% SIC.

Various tests have been conducted, such as bulk density/apparent porosity (EN 993-1: 1995), cold crushing strength (EN 993-5: 1998), thermal shock resistance (ENV 993-11: 2007), water quenching method, refractoriness under load (EN ISO 1893: 2008) and thermal conductivity (EN 993-15: 2005), which prove the product's thermo mechanical properties, alkali and thermal shock resistance.

Figure 2. Old lining, 2010.

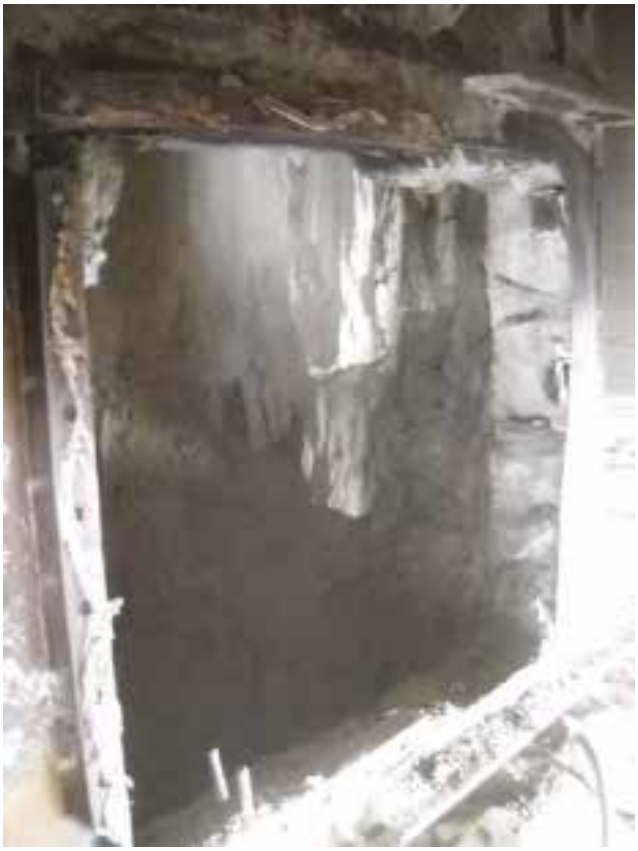
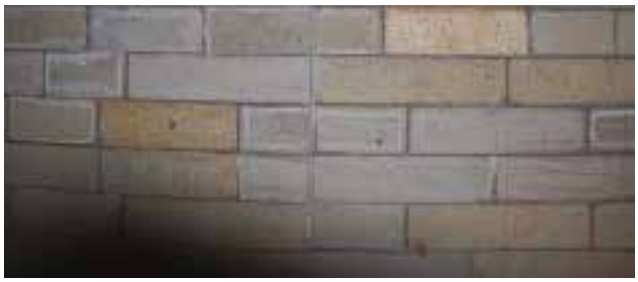


Figure 3. Installation of new lining, 2010.



The most important property of Alsic 500 is that it can stand alkalies and other substances circulating in the kiln system and does not create buildups because of the silicon carbide oxidation inside the brick.

Silicon carbide oxidation occurs according to the formula: SiC (s) + $2O_2$(g) → SiO_2 (s) + CO_2 (g), where SiO_2 (s) contains SiO_2, Fe_2O_3 + Al_2O_3 + alkalies.

The already created SiO_2 is a very viscous, glassy phase, covering and sealing the surface of the brick and it prevents substances from penetrating the kiln's atmosphere.

The micro photo in Figure 1 shows the surface of an Alsic 500 brick, where a thin line (glassy phase) is created on the surface.

Application areas include: riser ducts, cooler hot parts, kiln safety and cooling zones and sometimes the lower zone in the calciner.

Thus far, worldwide references for Alsic 500 include: Calderys Austria GmbH, Calderys Taiwan Co. Ltd, Cementa AB Degerhamn, Cementa AB Skovde, Cemex A.S, Ceskomoravsky Cement A.S, Ciments Lafarge, DD Fabrika Cementa Lukavac, Finnsementti, Gorazdze Cement S.A, Heidelberg Cement AG, Heidelberg Cement Georgia Ltd, Holcim (Cesko) A.S/Prachovice, Holcim GmbH, Hope Cement Ltd, Jsc Spasskcement, Lafarge UK Services Ltd, Marker Zement Gmbh, Norcem A/S, Norcem A/S Brevik, Platinum Controls Installations Ltd, Qatar National Cement Company, Unistara S.P.A, Southern Province Cement and Bazian Cement Company.

Riser duct, Finnsementti plant in Parainen, Finland

The plant's main fuels are coal and petcoke (minimum 1:2 from main burner) and alternative fuels up to 35%. The old lining experienced 20 – 30 cm buildup, where different castables have been tried without success. New lining had to be installed every year, with many shell repairs, lining problems during the production period, buildups (up to 200 – 300 mm), cracks, cavities, alkali penetration, lining abrasion and burned anchors all being reported.

New lining solution

Höganäs designed a new lining solution to overcome the problems, combining Alsic 500 bricks with anchor bricks in the hot face and using 612 Porosil G as a backup insulation layer.

After 3 years there were practically no buildups, the wall was without abrasion (bricks looked like new), no cracks had formed and there was no alkali infiltration. The performance of the Alsic 500 was exceptional, and clearly well suited to problems connected with alternative fuels, buildups and abrasion problems.

Kiln application at Spasskcement, Russia

Spasskcement plant operates the largest kiln in Russia. The kiln dimensions are 5.8/6.4/7.0 m x 95 m and production output is 3000 tpd. It was a Soviet design

Table 1. Physical analysis, DIN EN 993-1

	Vik 330 hot-face	Vik 330 40 – 50 mm	Vik 330 cold side	Alsic 500 hot-face	Alsic 500 40 – 50 mm	Alsic 500 cold side
Bulk density g/cm³	2.14	2.11	2.11	2.42	2.40	2.40
App. porosity %	17.0	17.7	18.4	19.7	20.3	21.0

Table 2. Chemical analysis, %

	Vik 330 hot-face	Vik 330 40 – 50 mm	Vik 330 cold side	Alsic 500 hot-face	Alsic 500 40 – 50 mm	Alsic 500 cold side
Al_2O_3	34.24	36.00	36.43	48.07	51.83	51.95
SiO_2	53.17	57.47	57.39	33.51	33.59	33.13
Fe_2O_3	2.10	2.21	2.21	1.68	1.63	1.74
TiO_2	1.32	1.40	1.44	1.93	2.02	2.13
CaO	1.77	0.29	0.28	2.45	0.28	0.26
MgO	0.46	0.48	0.40	0.29	0.27	0.25
K_2O	6.29	1.72	1.47	3.52	0.79	0.83
Na_2O	0.38	0.16	0.13	0.30	0.18	0.21
SiC	–	–	–	8.13	9.16	9.29

Figure 4. Lining after three campaigns, 2013.

originally constructed in 1976 and modernised by ThyssenKrupp Polysius (now ThyssenKrupp Resource Technologies) in 2011.

In May 2012, 195 rings of Viking 330 were installed after the inlet cone, followed by 50 rings of Alsic 500 before the upper transition zone. The location of Alsic 500 was determined in order to avoid liquid formation.

Viking 330 is the dry pressed version of Bjuf SX. Its main physical properties include:

- Low density (2.31 g/cm³) with high porosity (18%).
- The refractoriness under load T05 is equal to 1330 °C and T5 equals 1430 °C.
- Thermal conductivity at 500 °C is 1.8 W/mK, remaining 1.8 W/mK at 1250 °C.
- Important chemical properties are 35% Al_2O_3, 1.8% TiO_2, 59% SiO_2, 1.7% Fe_2O_3 and 0.4% CaO.

Its main characteristics are high porosity, alkali and abrasion resistance. It can eliminate buildup problems and withstand chemical attack in the form of alkali penetration, chlorine, sulfur and transition metals that occur in the lower cyclone stages, riser ducts, kiln inlets, calciners, smoke chambers and meal pipes.

Various tests were carried out on Viking 330, including: bulk density/apparent porosity (EN 993-1: 1995); cold crushing strength (EN 993-5: 1998); thermal shock resistance (ENV 993-11: 2007); water quenching method; refractoriness under load (EN ISO 1893: 2008); thermal conductivity (EN 993-15: 2005). The most important was the alkali test, or 'Cup' test, where Viking 330 showed alkali resistance (cm^2) <4, which is considered a very good result.

Worldwide references for this brick include the Arab Company for White Cement, Cement Hranice Akciova Spolecnost, Cement AB Degerhamn, Cementa AB Skovde, Cementa Slite, Cemex Polska SP.Z.O, Ciment de Sibline, Ciments Lafarge, Dyckerhoff Polska SP, Eastern Province Cement Company, FLSmidth & Co A/S, Finnsementti, Gorazdze Cement S.A, Heidelberg Cement Shared serv. Gmbh, Holcim GmbH, Hope Cement Ltd, JSC Lafarge Cement, Kapyfract AG, Lafarge UK Services Ltd, Nasicement D.D, Norcem A/S, Phoenix Zementwerk, Portland Zementwerk, Qatar National Cement Company, Unistara S.P.A, Southern Province Cement Co. and Yanbu Cement Company.

Of particular note at the Spasskcement plant was the 300 days kiln operation with 24 cold stoppages.

Figure 5. Left: Viking 330; right: Alsic 500.

Alsic 500 showed excellent performance with initial lining thickness of 250 mm and remaining 160 – 170 mm at the end of the 300 days.

Physical, chemical and optical microscopy analyses were carried out on Viking 330 and Alsic 500 samples, in order to prove their performance during kiln operation.

Results

The bricks were divided into two pieces and the structure looked very good from the hot-face area to the cold face (Figure 5).

The physical analysis showed rather small changes from the cold side to the hot-face area (Table 1).

Chemical analysis showed increased content of alkali and calcium in the hot-face area. Behind that area the chemical analysis are unchanged (Table 2).

The optical microscopic analysis showed Kaliophilite, $K_2O \times Al_2O_3 \times 2SiO_2$ in the hot-face area in both products.

In the Alsic 500 hot-face area there is also some Anorthite, $CaO \times Al_2O_3 \times 2SiO_2$ and an alkaline viscous glassy phase covering the pore system.

Conclusion

Both Viking 330 and Alsic 500 have behaved as expected by reacting and creating Kaliophilite, which in turn reduces the rate of further infiltration. In Alsic 500 there is also an alkaline viscous, glassy phase that further reduces the rate of infiltration.

Both samples in Figure 5 are divided into two pieces showing the structural hot face at the top of each image.

Alsic 500 has achieved remarkable results for applications in riser ducts and kilns. The lifetime obtained, as shown on the two above case studies, is three years in riser ducts and 300 days kiln operation with 24 cold stoppages. Moreover, Viking 330 is also a proven remedy for alkali, anti-buildup problems and alternative fuels combined in kiln inlet zones followed by Alsic 500 before the upper transition starts.