Fused Mullite-Zirconia

Castable compositions made from fused mullite-zirconia grain also exhibit good alkali resistant properties. Fused mullite-zirconia is often termed AZS, and is made by fusing high purity alumina and zircon sand. The resulting mineralogy in the grain is described as needle-like mullite crystals with co-precipitated monoclinic zirconia.

AZS materials have become prominent in refractory selection for buildup management, although it should be noted that most commercial AZS compositions also contain about 5% silicon carbide.

The alkali cup test for Resco's AZS castable, EZ CUBED® AZS, shows no cracking, very thin penetration and moderate cup adherence.

Figure 8. EZ CUBED® AZS is widely used in linings where buildup management is desired. This product contains about 5% silicon carbide receives an excellent rating in the alkali cup test.

QUIKTURN™ Products

Most of Resco's standard alkali-resistant and buildup management castable materials have QUIKTURN™ counterparts.

QUIKTURN™ denotes a special castable technology where initial dryout of the castable mass takes place at a more rapid pace than conventional low-cement materials. Two QUIKTURN™ products with noteworthy alkali resistance include QUIKTURN™ 60Z PC and QUIKTURN™ AZS PC.

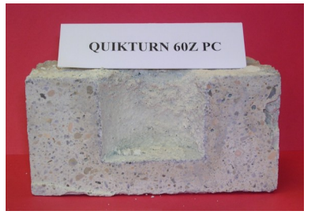

Figure 9. Alkali cup test of QUIKTURN™ 60Z PC shows no cracking, minor penetration and overall excellent alkali resistance.

Summary

Monolithic product selection in the cement kiln preheater is normally based on vessel temperature, position in the preheater and the conditions inside the vessel.

Higher cement castables and gunning mixes, such as RESCOCAST® 15GM, can be selected for the upper stages in a preheater where temperatues are below 1400°F (760°C), too low for alkali reactions. In the upper preheater, alkali attack is normally not prevalent.

The increasing temperatures in the lower preheater, including the lowest stage cyclone, duct, calciner and the kiln inlet, allow low-cement monolithic materials to excel.

Medium alumina content refractories exhibit superior alkali resistance over high alumina materials. Low-cement castables also have better alkali resistance. A low-cement castable with exceptional alkali resistance is EZ CUBED® 60 LQY. VIBROCAST® 60PC, QUIKTURN™ 45 PC and QUIKTURN™ 60PC are also widely used in preheater linings.

For dry-gunning applications, PROGUN® LC 50G and PROGUN® LC 60G maintain high physical properties and good alkali resistance.

Zircon and silicon carbide-containing castables are common selections for buildup-prone areas of the suspension preheater.

Zircon-enriched products like VIBROCAST® 60Z PC and QUIKTURN™ 60Z PC demonstrate superior alkali resistance and are formulated to help with buildup management.

Fused-mullite zirconia mixes include EZ CUBED® AZS and QUIKTURN™ AZS PC for pumping and shotcrete applications, and QUIKTURN™ AZS G for gunning installations.

Resco offers a wide variety of silicon carbide-containing mixes, including EZ CUBED® 56SCPC, EZ CUBED® 20-60, PROGUN® 56SCG, QUIKTURN™ 56SCPC and QUIKTURN™ 56SCG for products in the 50% to 60% silicon carbide range. Products with lower contents of silicon carbide are also available.

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PRODUCT SELECTION IN THE CEMENT PLANT SUSPENSION PREHEATER

RESCO PRODUCTS, INC.

Refractory selection of monolithic linings in cement plant preheaters is based on a number of factors including temperature, the existence of build-ups, alkali attack and to a lesser extent, abrasion.

Vessel Temperature

Over the past 35 years, the design of the suspension preheater has evolved with the major development being the addition of the calciner vessel. The calciner vessel is an additional combustion chamber that burns fuel with preheated air. This increases the temperature of the suspending gas stream and allows additional calcination of the cement kiln feed. The calciner vessel itself may operate at over 1850°F (1010°C), and in some cases, considerably hotter where combustion takes place.

Raw meal is introduced at the top of the preheater tower and becomes suspended in the gas stream. Since the preheater is a counterflow device, the lower vessels operate at progressively higher temperatures. By the time the meal is charged to the rotary kiln, the calcined meal may be hotter than 1650°F (900°C).

Alkali-refractory Reactions

Original equipment manufacturers usually specify alkali-resistant refractories in the lower preheater, typically the bottom stage cyclone, the kiln inlet and the riser immediately above the kiln inlet.

Alkali reaction with alumina-silica refractories occurs in two states. Between 1400°F and 2300°F, alkali attack is referred to as dry attack. This temperature range encompasses the entire cement kiln suspension preheater.

Above 2300°F (1260°C) alkali reactions causes melting. This is referred to as "wet" alkali attack. Under these latter conditions, changing the refractory to a higher alumina (more refractory composition) or a magnesia-based composition is generally required to extend refractory life.

In dry attack, the alkali vapor penetrates the alumina-silica refractory through the pore network. Alkali-alumina silicates form, which are expansive in nature, in that they occupy a considerably larger volume than the original refractory grains.

Since the primary alkali in cement production is potassium, the typical alkali compounds formed are leucite ($KAlSi_2O_6$), kalsilite ($KAlSiO_4$) and kaliophilite ($KAlSiO_4$).

Volume change leads to cracking and spalling, as the refractory cracks to relieve the stress caused by the expansion. Frequently the refractory becomes weak and friable as the bonding is disrupted from the expansion of the grains.

It is generally accepted that refractories containing high purity alumina and refractory bauxite are the most severely affected by alkali attack. Our testing also suggests that monolithic refractories that have high contents of calcium-aluminate cement can be more severely attacked.

Figure 1. Alkali attack in a high alumina castable caused cracking and friability in the refractory. Alkali reactions have discolored the grains and caused expansive growth.

Mullite ($3\ Al_2O_3$-$2\ SiO_2$) and fireclay containing refractories tend to be more resistant, and when formulated in low cement compositions, excellent alkali resistance results.

Laboratory testing

Using refractory cup tests is a traditional method to examine refractory-alkali reactions. A popular procedure is to pack sample cups with potassium carbonate, apply a lid, heat them to 2012°F (1100°C), and examine the sample for cracking, penetration and adherence of the alkali material.

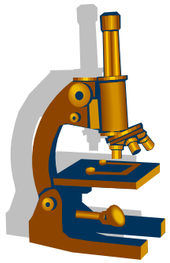

Figure 2 shows that a cup test sample of a 3200° F high alumina castable containing bauxite has cracked. Further inspection shows that the alkali has penetrated and discolored to a significant depth around the cup.

Among products with excellent alkali resistance is a low-cement castable based on medium alumina grain, EZ CUBED® 60 LQY. In the alkali cup test, this 55% Al_2O_3 product shows no cracking, excellent resistance to penetration and very little coating inside the cup. EZ CUBED® 60 LQY has demonstrated excellent resistance in service as well.

Figure 2. Alkali cup test of 80% alumina castable shows cracking from expansive phases formed and discoloration due to penetration.

Figure 3. EZ CUBED® 60 LQY is a 55% alumina shotcrete castable with outstanding alkali resistance.

Buildups

Since there use in cement production in the 1970's, undesirable coatings and buildups have formed on the vessel refractory linings of suspension preheaters. When the buildups impede the gas or material flow, manual removal of buildups causes interruptions in production. It is believed that buildups form when alkali salts condense from the vapor state, become molten and tacky on the vessel walls and cause the fine feed particles to stick. The role of a particular compound, spurrite ($Ca_5Si_2(SO_4)O_8$), has been suspected for a long time.

In the process, efforts should be directed to reduce chloride and sulfur levels, often by management of waste dust.

Other methods to reduce buildup-caused interruptions focus on installation of high pressure gas jets to blow the buildups off the vessel walls, increasing gas and material velocities.

From a refractory perspective, maintaining smooth faces in buildup-prone areas and selecting special refractory formulations can assist in the management of buildups.

Some of the earliest monolithic products applied to cement preheaters for build-up resistance contained zircon (ZrO_2-SiO_2). In low-cement castables, zircon can be a beneficial additive, even in small amounts. The mechanism that zircon helps a refractory resist buildups is not known. One theory suggests the formation of silica on the lining surface caused by the dissociation of zircon inhibits buildup-forming compounds.

An economical monolithic refractory product is a 60% alumina low-cement castable with a minor zircon addition, VIBROCAST® 60Z PC. This product renders excellent strength and is easy to install either by casting, pumping or shotcrete. VIBROCAST® 60Z PC exhibits an excellent alkali test cup, with no cracking, no penetration and no adherence of the alkali to its surface.

Silicon carbide (SiC) is another constituent favored for build-up management. The mechanism is again likely related to the availability of silica at the lining surface, but in this case, by the oxidation of silicon carbide. Silicon carbide levels in castables that have demonstrated some ability to repel buildups in service range from 5% to about 60%. Silicon carbide is an abrasive grain that is electrically fused, and is expensive.

Silicon carbide is also a very poor insulator, so linings that contain this material must have appropriate layers of insulation behind. Current thinking about preheater vessel shell temperatures is to maintain at least 300°F (149°C) to prevent acid gas condensation. A 60% SiC castable lining will require about 3" of an 80 pcf density lightweight castable material to approach this skin temperature (325°F to 350°F).

Alkali cup tests of high silicon carbide castable materials typically show no cracking, but reaction with the alkali charge and penetration are notable. Surprisingly the cups also have the alkali adhering to the walls.

Figure 4. VIBROCAST 60Z PC alkali cup test exhibits exceptional resistance, no penetration and a very clean cup.

Figure 5. After a year of service in this bottom stage cyclone roof, QUIKTURN™ 60Z PC, which contains a zircon addition, appears in excellent condition with no cracking and good resistance to buildups.

Figure 6. EZ CUBED® 20-60 contains about 60% silicon carbide. In the alkali cup test, no cracking was observed. The test cup indicates some reaction with the alkali.

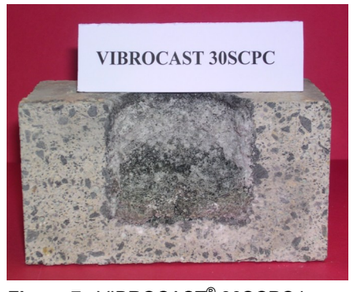

Figure 7. VIBROCAST® 30SCPC is an example of a medium SiC content product that receives a very good rating in the alkali cup test. No cracking detected and moderate penetration.