All-round ceramic protection

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Erosion can significantly reduce the operational life of cement production equipment and speed up the replacement of key components. The use of abrasion-resistant precast ceramic parts can be a sound alternative to expensive metallic shapes or cast refractory.

Limestone, pulverized coal (fuel), clinker dust, ash and other materials attack steel and alloy components when the media is transported about the plant. Predictably, over time, the abrasive nature of these materials will prevail against any metal surface because metal will eventually erode. However, ceramics offer an effective solution against erosion.

Often engineers and maintenance personnel are tasked with making attempts to extend the life of this equipment. A typical engineer in a cement plant will have some experience with and knowledge of metallurgy but will have little experience with the advantages of ceramic parts. As a result, engineers will often recommend a more expensive metallic solution to replace or protect existing processing components rather than ceramic solutions.

Laboratory and field tests have shown that ceramics do very well in sliding or low-acute-angle abrasion when compared to metallic parts. The one exception is that metallic parts do show an advantage in direct impact or 90° impingement. Because most metals are ductile in nature, they simply deform in direct impact situations. Very little material is actually removed from the base material – it is simply 'moved around.' This is why in most impact situations a softer metal often performs better than a harder one or ceramics from an erosion standpoint.

For example, ceramic specialists at Blasch have tested the abrasion characteristics of AR400 Steel and 309 stainless steel at 90° impingement. The stainless steel consistently performs much better and loses less metal over time.

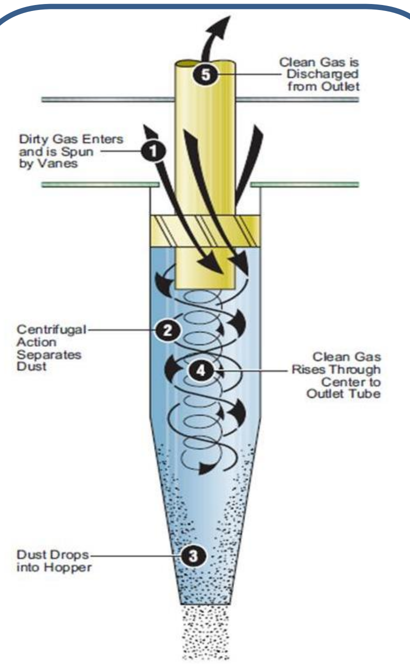

Figure 1: Ceramics can eliminate metal erosion in mechanical dust collectors where dust laden gases can cause severe damage.

Figure 2: These metal cones removed from a mechanical dust collector show trpical failure areas caused by dust laden gases eroding the metal.

Ceramic choices

Ceramics are capable of handling abrasion, high temperature and corrosion, often all at once. There are many grades and compositions of ceramics available to a plant engineer, including – and in order of increasing wear resistance – alumina oxide, oxide-bonded silicon carbide (OXYTRON™), nitride bonded silicon carbide (NITRON™), alumina-bonded silicon carbide (ALTRON™) and reaction-bonded silicon carbide (InVinCer by Blasch™).

The nature of wear in ceramics is very interesting when examined closely. Depending on the material, ceramics are often composed of several different sizes of raw material or grain. These grains are then in effect glued together with a ceramic binder matrix of some form or another. Both the

Figure 3: These OXYTRON ceramic cones have been in use for more than 12 years and show no signs of wear or wall degradation.

grains and the binder are mechanically-brittle materials and, as such, do not deform plastically to any large extent before failure. That limits their ability to absorb mechanical shock. In a 90° impingement abrasion situation, the combination of binder and grains must absorb all the energy of the impacting particles. Abrasive wear occurs as the binder matrix progressively fails due to these continuous small impacts. When enough of these grains separate, the part may fail or expose the item it was trying to protect.

However, in a cement plant, the majority of flow is parallel to the surface or via sliding wear. These particles collide with the steel components and cause extensive surface erosion. In advanced stages of erosion, the components get perforated and may fail once they lose their structural integrity. Such erosion shortens the service life of the equipment. Once this happens, the unit has to be shut down to replace damaged components, typically during an outage (with luck, a planned one). The resulting penalty is not only the cost of replacing components but also halting production.

Four options explored

Ceramics can provide effective wear protection in several areas of the cement plant. Examples include mechanical dust collectors, clinker cooler heat exchanger inserts, precast ceramic thimbles and pipe spools, elbows, valves and nozzles.

Mechanical dust collectors

There are many forms and techniques to clean up the dust-laden clinker gas before it exits the stack, such as the multicyclone dust collector (MDC). As opposed to one large cyclone over 5ft in diameter, a higher quantity of smaller (less than 24 in-diameter) elements are used. They are often employed to pretreat the gas before the baghouse. The elements consist of an inlet cone, outlet tube, and spin vane, sometimes called 'spinner' or 'ramp.' As shown in Figure 1, dust-laden gas enters the inlet cone. The spin vane imparts a cyclone action, where the larger particles fall out the bottom and the hot, cleaner gas exits the center of the outlet tube. The gas will then move to another piece of equipment for finer collection and cleansing.

`Although the gas directly impinges on the spin vane, it eventually converts to sliding abrasion and the inlet cone will develop holes over time that will allow the ash to bypass the collection process (see Figure 2). During every maintenance outage, several dozen elements often require replacement. Traditionally, cast iron is the material of choice, but in a few instances, NiHard or other metals with a high Brinell hardness have been used in an effort to extend part life. These moving parts are candidates for replacement or lining with ceramic.

Over 15 years ago, Blasch started replacing dust collector metallic parts with its proprietary OXYTRON material. OXYTRON is a silicon carbide-based material that is one-third the weight of steel and far outlasts the existing metallic components. One particular plant was replacing 50-100 elements every 1-3 years. It now has its complete MDC equipped with OXYTRON MDC parts, and the collectors show no signs of wear after many years of operation (Figure 3).

Clinker cooler heat exchanger inserts

Most cement plants use an air-to-air heat exchanger with metallic tubes to cool the clinker dust gas or steam before it flows to the baghouse. Hot, ash and dust-laden gas will travel into tubes at high velocity and elevated

Figure 4: OXYTRON Ceramic Clinker Cooler Inserts were installed at this cement plant to eliminate erosion of the inlet.

temperatures while a cross flow of cooler clean air will filter over the tubes cooling the gas. The inlet and outlet ends of the tube particularly are subject to wear as the gas often has to take a 90° turn while it enters/exits the tubes. Over time, dust in the gas will erode the tube to the point where holes and leaks occur, requiring tube replacement. In severe cases the tubesheet holding the tubes also erodes. A common solution is to weld patch panels over the tubesheet or use cast metallic sleeves with flanges on them, but this is only a temporary fix, as metallic sleeves need to be replaced often.

Ceramics offer a better long-term solution when the plant engineer has a choice between accepting excessive downtime to repair eroded components or making a change to equipment that is more abrasion resistant.

Blasch has developed a very thin-walled ceramic wear insert cast in its OXYTRON material. Ranging from 1-3ft long depending on the severity of the wear, these inserts protect the inlet and outlet ends of the boiler tubes, where abrasive wear is prevalent. This is the area where dust-laden gas must make an abrupt change in direction as it flows over a tube sheet. The ash-laden gas will erode the weld and first foot or so of the boiler tube, up to the point where the flow normally becomes laminar. Blasch's OXYTRON Clinker Cooler Inserts can be used to protect these areas and when used in conjunction with a poured castable face or engineered ceramic face plate, it provides a permanent total solution. Clinker cooler inserts are often used to protect newly-installed cooler tubes but can also protect worn-out existing tubes that are close to replacement (Figure 4).

Precast ceramic thimbles

Metallic thimbles are standard in the preheater section of the cement process. In conjunction with the cyclone, they provide high separation efficiency. Quite often due to the elevated temperature, the lowermost cyclones feature a cast, segmented design with a hanging suspension system. This is to allow the cylinder to grow and contract during heat-up and cool-down to prevent buckling, warping and eventually failure under those extreme conditions. It also enables easy installation and maintenance as it seems to be an area where constant attention is paid.

With Blasch's casting process the company is able to cast these panels in its NITRON ceramic. With its high strength and wear resistance, coupled with its shape capability and repeatable tight tolerances, it is a suitable replacement material for these thimbles.

Typical preheater temperatures are of no issue to NITRON which can withstand temps up to 1550°C (2800°F). The panels are also one-third of the weight of steel, making for an easy installation and replacement if required. The abrasion resistance of the NITRON material far exceeds any metallic component, especially with the sliding nature of the wear (see Figure 5).

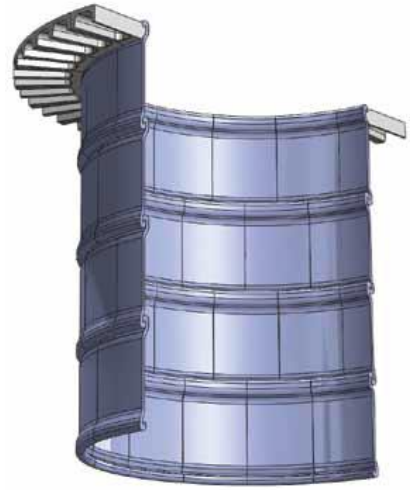

Figure 5: NITRON engineered precast ceramic thimble assembly

Pipe spool, elbows, valves and nozzles

The raw materials and finished products in the cement manufacturing process often have to be conveyed in piping, through valves, nozzles, chutes, hoppers, etc. If the material has to make a turn or be diverted often abrasion takes place in this area. Rubber, polyurethane and sometimes dense alumina tiles are frequently used to line these pieces of equipment.

> As a one-piece component, ALTRON will often replace a complex, several-hundred-piece assembly, therefore eliminating most, if not all, of the joints and seams.

However, there are many areas where ceramic can be used to extend the life or reduce maintenance. In cases of erosion caused by sliding abrasion, ceramic is a good replacement over metallic or rubber components. Ceramic liners can be cast into TEE & WYE shapes, reducers, elbows, laterals and numerous other profiles to reduce abrasion (see Figure 6).

Although there are several types of ceramics that can be used in these areas, the weak link in all of these applications is the method of attachment and assembly. Small alumina tiles are often used to line an elbow or piping system. The tiles are typically glued together and bonded to the steel. The weak link is the joint or seam. Over time, particles will erode the joints, or expansion/contraction due to temperature can cause the tiles to fall out or, worse, causing the steel behind it to erode, leading to ultimate failure and down time. Therefore a reduction or even elimination of the number of joints will contribute significantly to life of a component.

Blasch's silicon carbide-based material, ALTRON, can be cast in large complex shapes like pipe sections, elbows, chutes, cyclones, cones, and similar components. As a one-piece component, ALTRON will often replace a complex, several-hundred piece assembly, therefore eliminating most, if not all, of the joints and seams. The silicon carbide also is a much more abrasion-resistant material as compared to alumina tiles, providing added performance and reliability.

Figure 6: Ceramic liners made from ALTRON can be molded into just about any shape.

Conclusion

Cement plant engineers looking for improved ways of extending equipment lifespan can expect to find effective replacements in ceramics. The sliding and low-acute angle abrasion commonly found in cement works offers an ideal application of ceramics.