The benefits of internal coating and other flue gas vessels

Corrosion of steel in cement kilns and other flue gas vessels such as stacks, bag houses and scrubbers can result in equipment failure, plant shutdowns, loss of production and remediation of affected areas (see Figure 1). Severe instances may compromise plant personnel safety. A cement plant kiln is considered the most important part of the plant. Production is dependent on the kiln's efficient, continuous operation.

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'Without a barrier coating, surface substrates deteriorate at an aggressive pace, leading to premature equipment failure and replacement. The cost of applying these coatings is minimal in comparison to the loss of productivity, replacement and lost production revenues.'

Steel corrosion in the interior portion of these vessels and stacks can result in more aggressive deterioration of the steel substrate than exterior corrosion, reducing the steel thickness from the inside out. It is imperative to find a cost-effective, time-efficient solution. However, the application of protective linings to these systems is providing positive results. The purpose of this article is to describe the situation and the findings of internal kiln lining case studies and present an ongoing study for flare stack internal linings.

Situation

Residue of the products burned in the kiln pass through the porous refractory brick insulation of the interior shell and come to rest against the cold steel face wall of the kiln. Corrosion is initiated in the presence of moisture and thus the corrosion progresses at an alarming rate. Reduction of shell thickness per million tonnes clinker production ranges between 140–200mm, resulting in annual repairs. The challenging solution is to find a heat- and chemical-resistant coating that can tolerate the environment without any detrimental effect on production. The following case study began in March 2001 when a kiln lining was applied to a portion of the upper kiln. Subsequent applications were applied in March 2002 and April 2003.

However, kilns are not the only plant equipment suffering from exposure to corrosive agents of this kind. It is important to recognise the need for an internal coating system to be used in bag houses, stacks, scrubbers and other vessels exposed to a similar environment.

An example of untreated kiln corrosion

In March 2001, the company was presented with an interior kiln shell with a diameter of 6 × 4m. The area presented was located in the upper part of the kiln. The original estimated steel thickness ranged between approximately 111 to 254mm. Inspection took place following the removal of refractory brick from the area during plant outage. The appearance of the substrate surface revealed severe corrosion. Numerous areas of pitted steel and peeling delamination were found. The delamination appeared to be approximately 1.6mm thick (see Figure 1).

The surface was abrasive blasted to a SSPC-10 near white blast with a profile of 0.025mm, as specified by the Steel Structures Painting Council[1]. An application of aluminium-filled, silicone-based, heat- and corrosion-resistant coating was then spray-applied to the surface substrate at a dosage of 4.0 wet mils thickness, which would dry at 1.5 dry mils thickness. The coating was aqueous-based volatile organic compound (VOC) compliant and would be dry to touch and handle within two hours after application, prior to installation of new refractory bricks. Full curing would occur when plant went back into service. This full procedure was performed within one eight-hour shift.

The effect of coatings

In March 2002, the company was presented with a different portion of interior kiln shell wall with the same area. It would have had the same original shell thickness and was experiencing the same type of deterioration. The company was also allowed to investigate part of the steel that had been coated one year previously and no further delamination of steel thickness was found. The coating was still evident on much of the surface and the substrate appeared smooth, with no evidence of deterioration (see Figure 2).

(Photo: Ashcoat LLC.)

Figure 1: The example of severe corrosion was found on the untreated internal surface of a cement kiln.

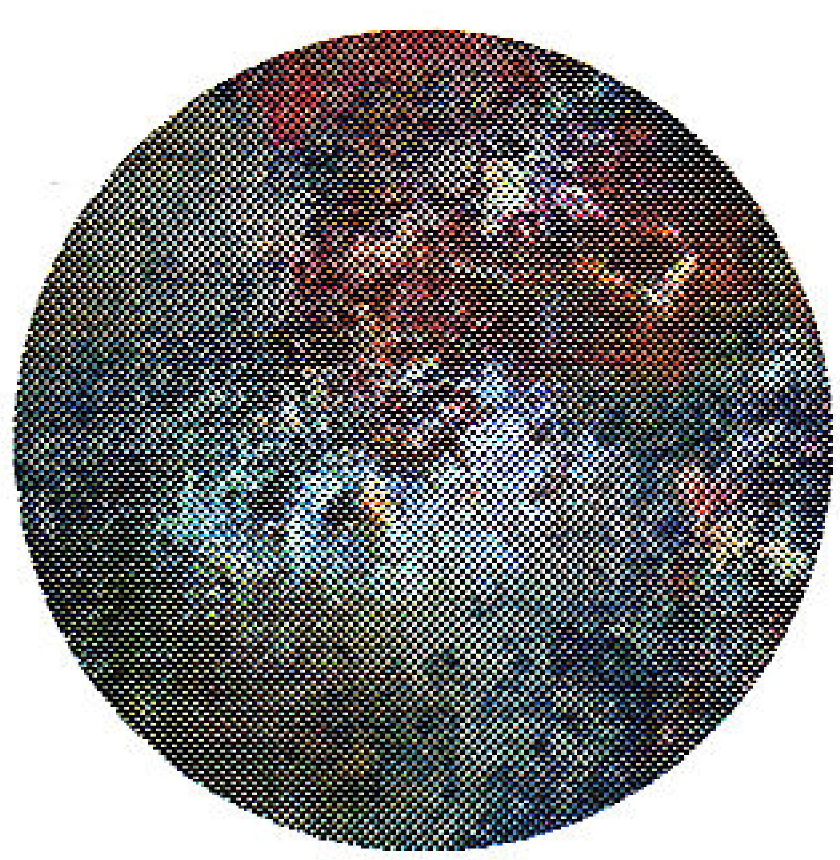

Figure 2: The kiln wall coating one year after application.

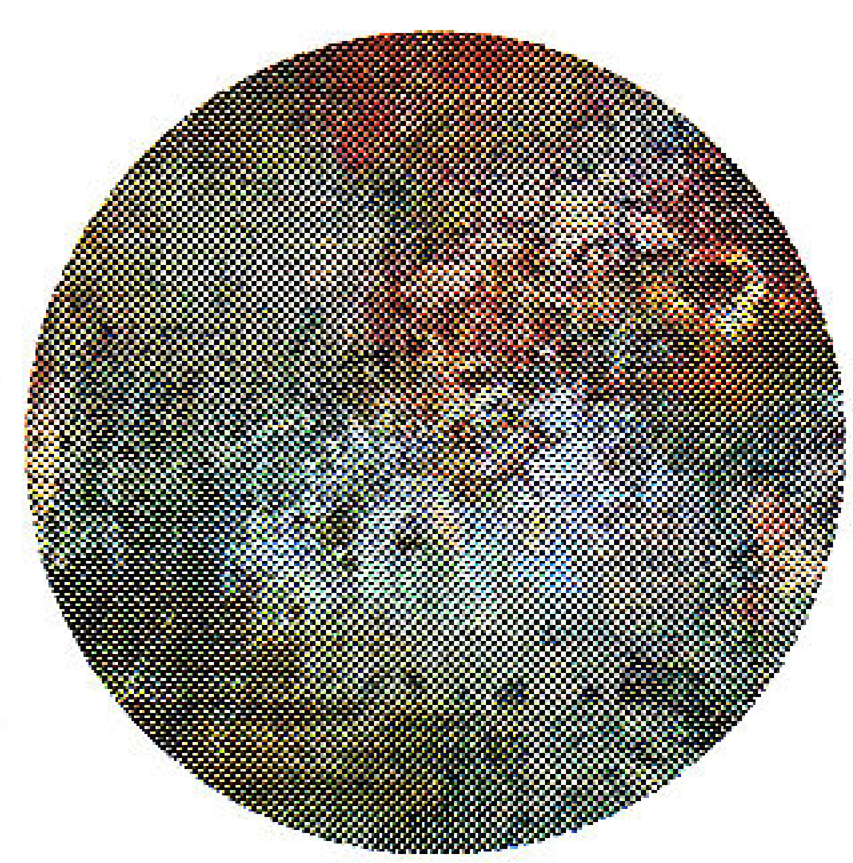

Figure 3: The kiln wall three years after application.

applications for cement kilns

The substrate of the new, hitherto untreated area, was blasted to SSPC-10 and the same coating was applied as before.

Study and application: April 2003

In April 2003, the company was presented with an additional 18.3m of the same kiln shell. Conditions, preparation and applications were the same as before. Time constraints did not make it possible to investigate previously treated areas for inspection. However, these areas were inspected during the June 2004 outage. There was evidence of coatings remaining intact and, furthermore, the appearance of the coated substrate appeared to be improved and smoother when compared with the uncoated substrate. This indicated that the density loss of steel was significantly reduced with the internal coating. This demonstrates that the protective coating has created a sacrificial barrier between the corrosion and steel, slowing the rate of deterioration due to corrosion (see Figures 3 and 4). A coating was applied to approximately 30.5m, located close to the burn zone. The material used was specified to withstand a higher temperature than the material for the upper section. Research will be undertaken to establish the status and condition of the coating at future dates.

Flare stack interior shells

There is a main flare stack of the preheating tower in most cement plants. Gases derived from the by-products burned in the kilns are expelled through this stack and are thus exposed to an aggressive environment akin to that of the kiln. Figure 5 shows how a flare stack interior has corroded. The stack was approximately 57m tall with a diameter ranging from 4–6m. This was exposed to a similar environment, but heat exposure was not as great as that of the kiln. The operating temperature of the stack is approximately 140°C, but once a week the temperature would rise to approximately 180°C. The degree of corrosion varied at different heights within the stack, thereby indicating that exposure to moisture and chemical attack is greater in those areas.

The substrate was abrasively blasted to an SSPC-10 near-white blast profile of 0.025mm. A high-performance silicone-based coating was spray-applied to a prepared surface at approximately 7 wet mils per coat which would dry at 4–5dft (dry film thickness) per coat. Three coats were applied to achieve a total dry film thickness of 14–15dft. Research will be undertaken the status and condition of the coating in the future (see Figure 6).

Solution

The available data indicates that treating the corrosion attack from the interior portion of the vessel is successful because:

- the media blasting of the interior kiln shell, flare stack and other related vessels removes chemical debris and contaminants from the substrate which can initiate corrosion.
- the application of a heat- and corrosion-resistant lining to the cleaned substrate creates a sacrificial barrier between the chemical contamination and the shell walls. This slows the corrosion rate of the interior shell walls.
- slowing the corrosion rate extends the life of the shell, thereby extending service life. It also enables the plant management to budget for future equipment needs.

Concluding remarks

This study illustrates how coatings extend the service life of cement kilns, stacks and similar vessels. Without a barrier coating, surface substrates deteriorate at an aggressive pace, leading to premature equipment failure and replacement. The cost of applying these coatings is minimal in comparison to the loss of productivity, replacement and lost production revenues.

'This study illustrates how coatings extend the service life of cement kilns, stacks and similar vessels. Without a barrier coating, surface substrates deteriorate at an aggressive pace, leading to premature equipment failure and replacement.'

Reference:

1. STEEL STRUCTURES PAINTING COUNCIL. SSPC-SP COM *Surface preparation commentary for steel and concrete substrates*, website: www.sspc.org/standards/spscopes.html, The Society for Protective Coatings, Pittsburgh, 2000.

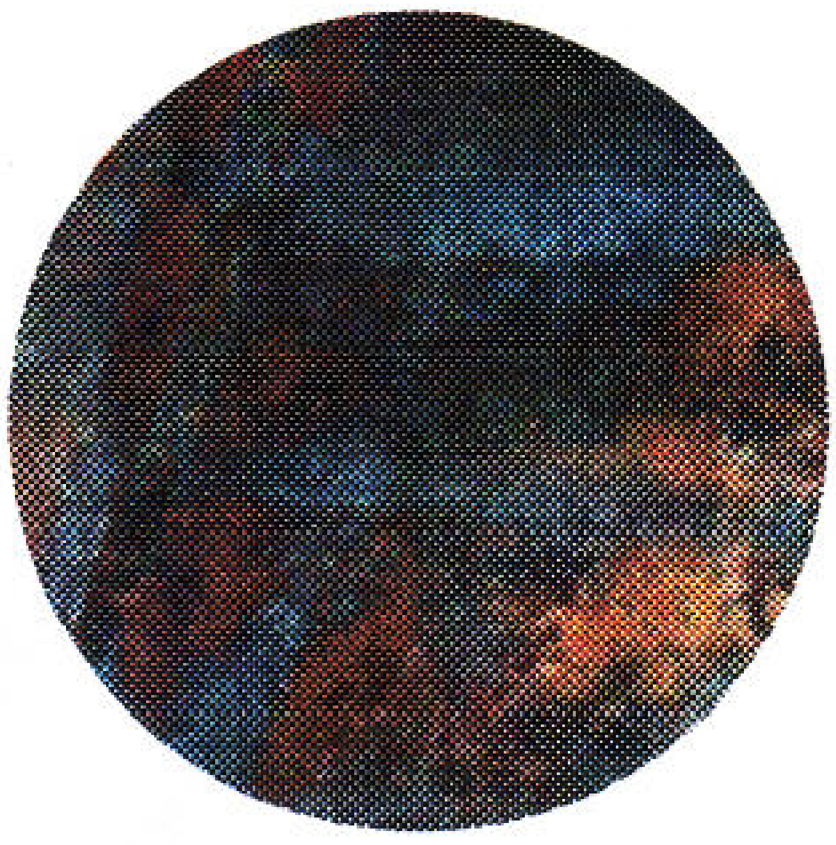

Figure 4: The same wall four years after application.

Figure 5: Advanced corrosion on the internal wall of a flare stack.

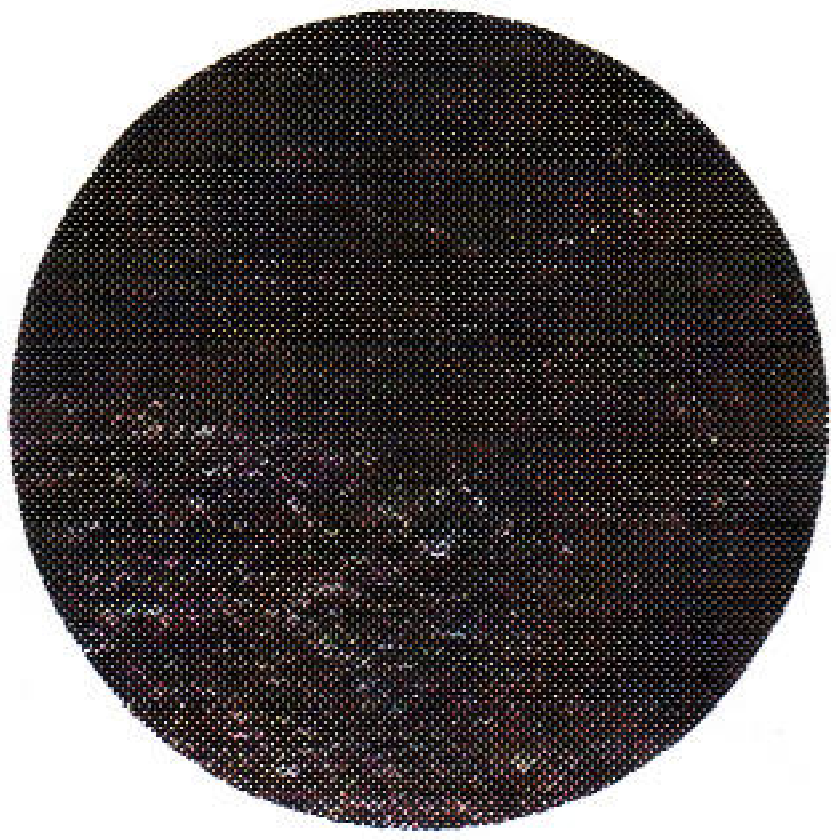

Figure 6: The coating applied to the internal wall of a flare stack.

DRAFT

Combating Corrosion

Debra Ashley, Ashcoat, LLC, USA, presents a study based on corrosion attack to the interior kiln shell wall, and discusses the benefits of internal kiln coating applications.

Introduction

Corrosion attack in cement and other flue gas industry facilities can produce major problems such as equipment failure, plant shutdowns, loss of production, and replacement costs of new steel. In severe instances, the safety of plant personnel can be compromised.

The kiln of a cement plant is considered to be the 'heartbeat' of the plant. The production and revenue of a plant depend on the kiln's efficient and continuous operation.

Corrosion found in the interior portion of the kiln shell walls can have a more aggressive deterioration rate to steel substrate than exterior corrosion, compromising the integrity of the steel's thickness from the inside out. In today's competitive environment, extending the life cycle of kilns is increasingly important. The application of protective coatings and linings to the interior kiln shell walls has so far provided encouraging results. The following describes the problem, and a cost effective and time efficient solution resulting from the company's case studies of internal kiln linings.

Situation

Residue from products burned in the kiln leach through the porous refractory brick insulation and adheres to the cold face wall. Chemical reaction occurs in the presence of moisture during kiln shutdown, causing corrosion that accelerates at an alarming rate. In some cases, the deterioration of shell thickness could be 0.055 in. of corrosion per million t of clinker production to 0.078 in. This results in costly premature steel replacement, which was previously considered acceptable throughout the industry.

The solution is twofold:

- Find a heat and chemically resistant coating that will tolerate the aggressive environment.
- Be capable of performing an application procedure in conjunction with plant shutdown without causing any additional delays to the scheduled outage.

The following case study began in March 2001 with a test application of kiln lining to a portion of the upper transition, with subsequent applications to other portions of the upper transition in March 2002 and April 2003.

Study and application: March 2001

In March 2001, the study began with a surface preparation and test coating application of approximately 20 ft x 13 ft 6 in.dia. of interior kiln shell. The area was located in the upper transition of the kiln. The original estimated thickness of steel was approximately 7/16th in. to 1 in. The inspection of this area took place during normal plant outage following the removal of refractory brick. The appearance of the surface of the substrate revealed severe corrosion. Numerous areas of pitted steel and an orange peel type of delamination of steel was also sighted (Figure 1). The thickness of delamination appeared to be approximately 1/16th in.

The surface was abrasive blasted to a SSPC-10, near white blast (0.001 in. profile). An application of a heat and corrosion resistant coating was applied. This coating was a binding system of an aluminum filled, silicone-ceramic aqueous based material. The coating was applied by conventional spray method to surface substrate at 4.0 mils wft (wet film thickness) and would dry at approximately 1.5 mils dft (dry film thickness) per coat. The full procedure was performed within one eight hour shift. The coating was dry to touch and handle within two hours after application, thus allowing refractory personnel re-entry to complete installation of the new refractory without undue delay. Full cure occurred when the plant went back into service.

Study and application: March 2002

In March 2002, an additional 20 ft of upper transition of the same kiln was awarded.

An initial inspection revealed severe and pitted corrosion throughout, and areas of orange peel type delamination were sited.

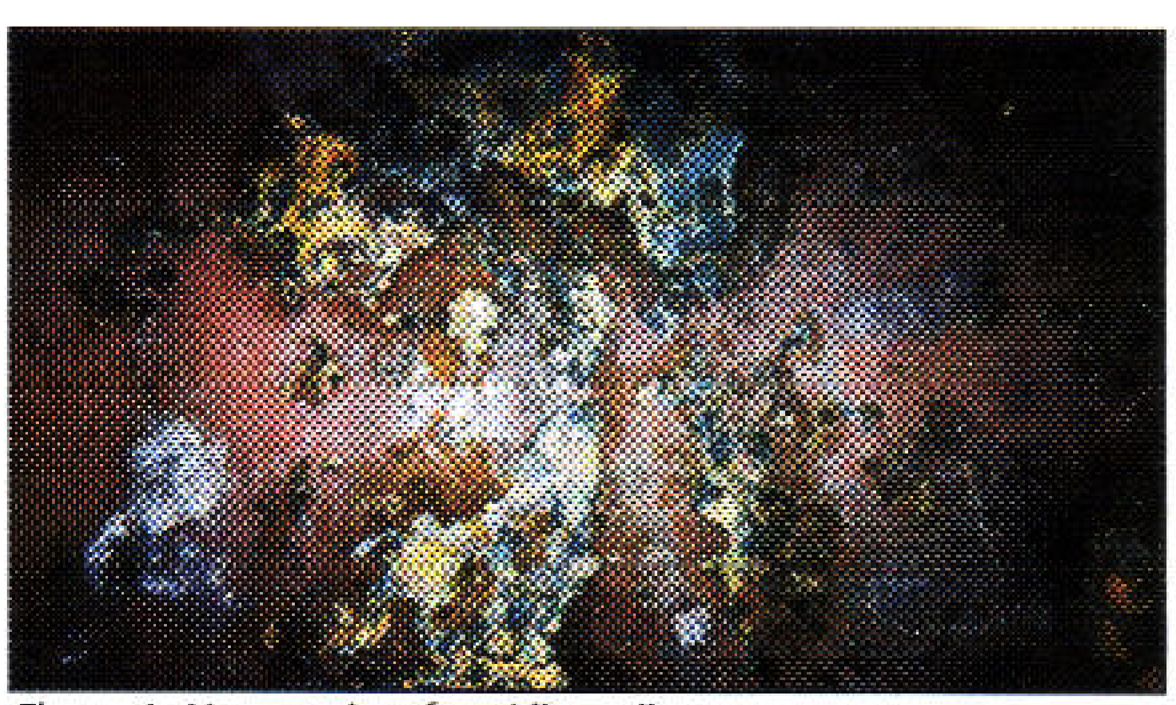

Figure 1. Uncoated surface kiln wall.

Figure 2. Inspection of 2001 coating one year after application.

Figure 4. Inspection of 2002 coating two years after application.

The original shell thickness was estimated to be between 7/16th in. and 1in. The section was coated with the same product following the same preparation and application procedures as above.

At this time, Ashcoat was allowed to inspect an area from the first application of March 2001. The inspection revealed no delamination of steel thickness, and the coating could still be seen intact in much of the surface. This result appeared to be a significant success, as there was no evidence of steel density loss, and the coating still seemed intact, which was more than had been hoped for at that time (Figure 2).

Study and application: April 2003

In April 2003, Ashcoat was presented with an additional 60 ft of same kiln shell located in a different portion of the upper transition of the kiln shell.

Inspection of this area revealed similar corrosion as previous areas.

Preparation and applications of the coating were the same as the two previous applications. Time constraints did not make it possible to open up previously treated areas for inspection at this time.

Study and application: June 2004

During this shutdown, approximately 100 ft of new kiln shell, which was to be erected near the burn zone area of the kiln, was awarded. The material was specified to withstand a higher temperature than the material for the upper transition.

At this time, the company was allowed to inspect portions from previously coated sections as follows:

Inspection of application - March 2001

Figure 3 illustrates the area which was washed and cleaned of surface rust and pollutants to expose steel substrate. This not only shows some areas of coating remaining intact, but a smooth surface to those areas with no significant evidence of delamination or pitting compared to the original inspection, and indicates that the coating created a barrier between the contaminates and substrate.

Inspection of application - March 2002

The substrate was washed and cleaned of surface rust and pollutants before the inspection and photographs were taken. On examination, much of the coating remained intact with significantly smoother surface to coated areas than the uncoated areas of the same piece of kiln shell.

Inspection of application - April 2003

The substrate was washed and cleaned of surface rust and pollutants. An inspection one year after the application revealed the existing coating to appear intact with a significantly smoother surface to coated areas than the uncoated areas of the same piece of kiln shell (Figure 5).

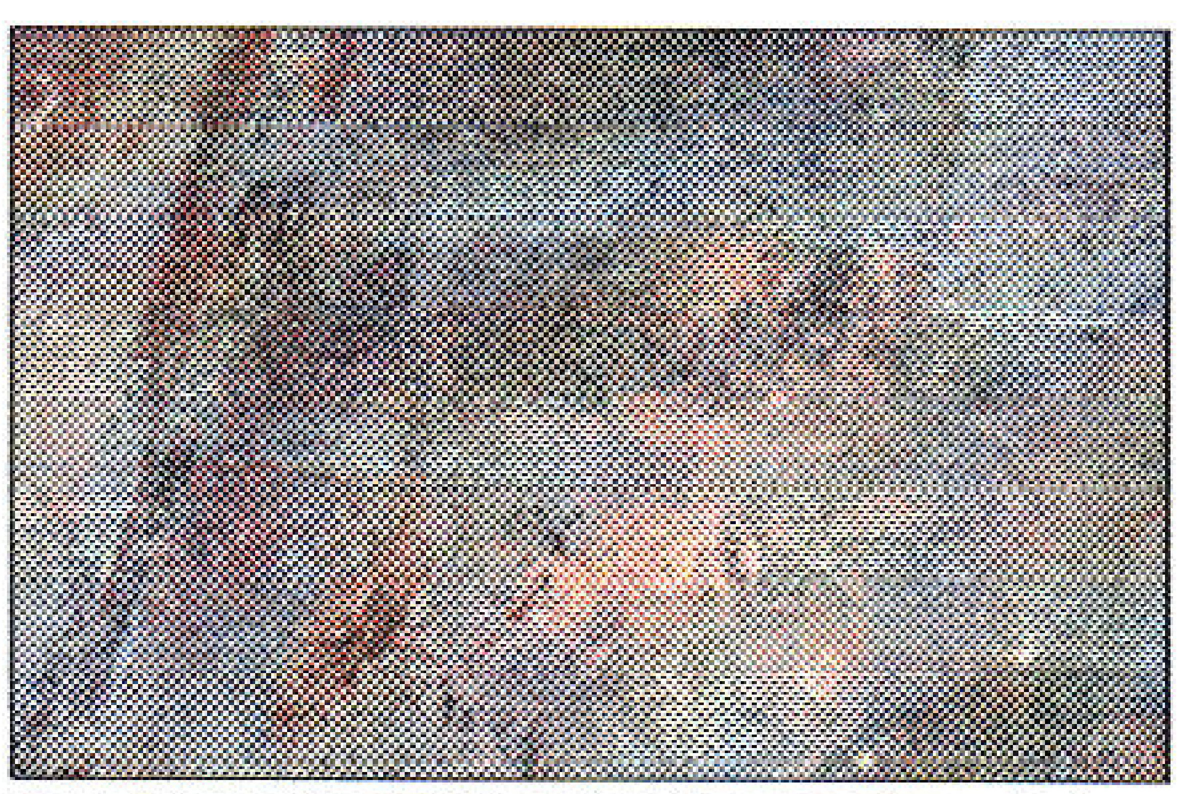

Figure 3. Inspection of 2001 coating three years after application.

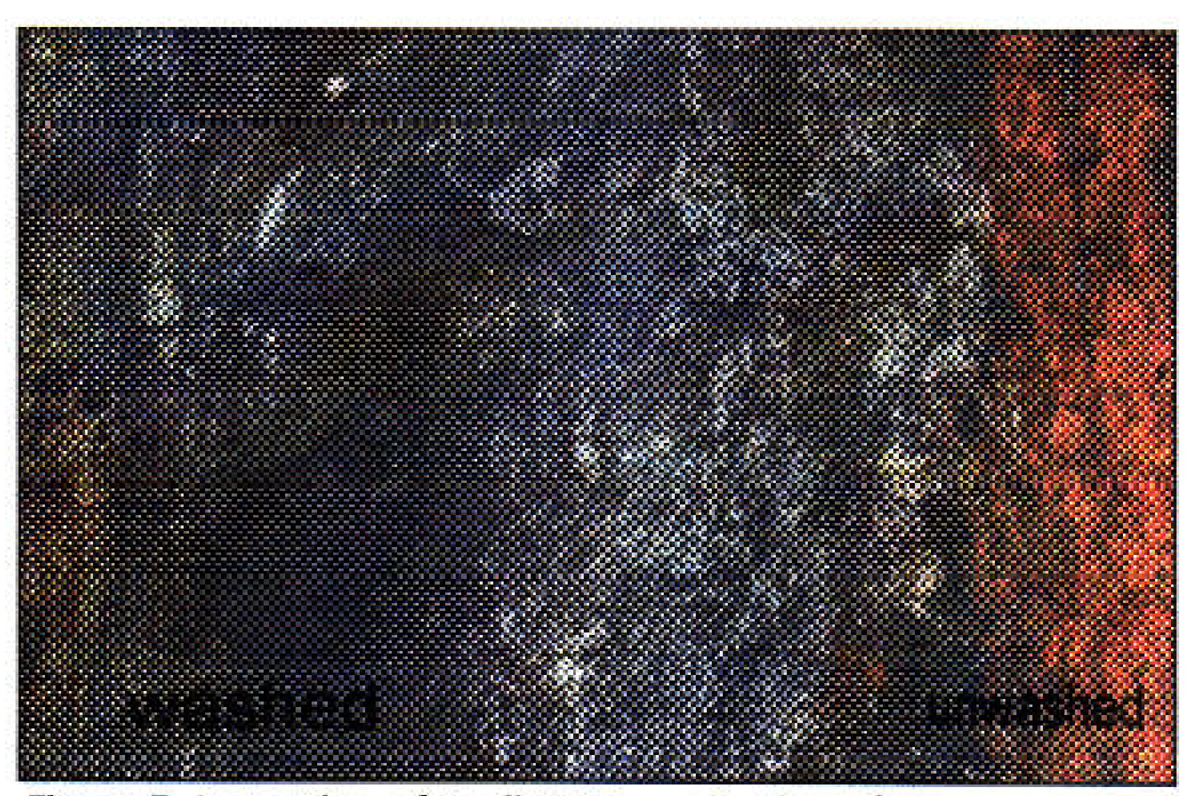

Figure 5. Inspection of April 2003 application after one year.

Solution

With the available data from case studies over the past three years, it appears that Ashcoat's recommendation of treating the corrosion attack from the interior portion of the vessel has been successful for a number of reasons, which include:

- The media blasting of the interior kiln shell removes chemical debris and contaminants from the substrate, which can be the catalyst for the onset of corrosion.
- The application of a heat and corrosion lining to the cleaned substrate creates a barrier between the chemical contamination and the shell wall. This process retards the progression of corrosion deterioration (slows down the rate of corrosion) to the kiln wall's thickness.
- Slowing down the rate of deterioration to the shell's thickness in turn extends the life of the shell, thereby providing the plant extended equipment service life while saving expensive replacement costs and down time. It also allows the plant personnel time to budget for future needs of the equipment.

The duration of the coating's endurance will be dependant on each plant's maintenance and operational service to their kiln, equipment, and kiln refractory they decide to use.

Conclusion

In the opinion of the author, based on field testing, the application of temperature and corrosion restraint coatings to the internal kiln wall extends the service life of kiln equipment without impeding the plant's productivity.

Without a barrier resistant coating, it is known that surface substrate deteriorates at an aggressive pace, which leads to premature equipment failure and expensive replacement costs.

The costs of this application process are minimal compared to the cost of kiln shell replacement, and the loss of plant productivity.

In today's market, plant management simply cannot afford to waste time, money or equipment. Production plants need to improve production performance in order to survive in today's competitive market place.

It is the company's belief that the implementation of an internal kiln protective coating procedure in the overall maintenance plan is a cost productive and necessary tool, which should be included in the cement industry's maintenance budget. ◆