The Benefits of Internal Coatings

Debra Ashley, Specialized Coating Technology, LLC, USA, describes the benefits of internal coating applications to cement kilns, baghouses and other flue gas equipment.

Introduction

Corrosion of steel in the cement industry, such as in kilns, baghouses, flare stacks and other flue gas equipment, causes deterioration at alarming rates. Cement plant production and revenues are dependent upon the continuous and efficient operation of this equipment. Without the use of internal barrier coatings, the aggressive pace of deterioration causes premature equipment failure, costly steel replacement and unscheduled downtime. Effects of this corrosion are also becoming safety issues for plant personnel. Case studies regarding applications of internal coatings in the cement industry are providing positive results; these applications have increased the service life of this equipment by several years at a fraction of the cost of replacing the steel - steel that would have been lost or replaced at incredible costs, causing undue hardship to the plant's maintenance budget. This article provides case studies relating to internal kiln and internal baghouse coatings, and for flare stack internal linings and coating of refractory anchors.

Case study - kiln

Residue of the products burned in the kiln passed through the porous refractory brick insulation and adhered to the kiln's internal cold face wall. This residue chemically reacts with the presence of moisture and temperature change, thus resulting in corrosion. The corrosion rate to the interior substrate progresses at a much higher pace than that of the external corrosion. In some cases, the deterioration of shell thickness can be 0.055 - 0.078 in. of corrosion per million t of clinker produced. This results in premature equipment failure and steel replacement.

The solution:

- Find a heat resistant and chemically resistant coating that can tolerate the aggressive environment.
- Perform the preparation of steel substrate and application of the coating in conjunction with safe plant shutdown, without causing the plant any additional delays.

The following case study began in March 2001 with a test application to a portion of the upper transition of the kiln lining, with subsequent applications to different areas of the same kiln in March 2002 and April 2003. The results were quite successful and, as a result, the plant has been implementing these internal kiln coatings on a routine maintenance basis for the past several years.

Application

In March 2001, the applicator was presented with a 20 ft. long x 13 ft. 6 in. dia. section of the internal kiln shell. The original steel thickness of the shell was approximately 0.5 - 1 in.

Figure 1. Corrosion of an untreated kiln.

Figure 2. Inspection of 2001 kiln coating three years after application.

Figure 3. Internal baghouse inspection in 2004, prior to coating application.

thick. Inspection of this section took place during standard plant outage, following removal of the refractory brick. The appearance of substrate revealed severe corrosion. Numerous areas of pitted steel and orange peel delamination were apparent (Figure 1). The thickness of delamination appeared to be approximately 0.0625 in. steel loss.

The surface was abrasively blasted to SSPC -10, near white blast (0.001 in. profile). A heat and corrosive resistant coating was applied. This coating was an aqueous based, aluminium filled, silicon ceramic-based material. Coating was applied by spray method conventional system at 4.0 mm wet film thickness (wft) and would dry at 1.5 mm dry film thickness (dft) per coat for two coats, totalling 3.0 mm dft. The full procedure was performed within one eight hour shift. The coating was dry to touch within two hours after application, thus allowing refractors to re-enter to complete installation of new refractory without delay. The full remedy would occur when the plant returned to service.

In March 2002, an additional section of kiln shell was awarded. Initial inspection revealed substrate appearance similar to the March 2001 inspection of the previous section. Preparation and application to this section was the same as in the previous application. During this 2002 outage, the applicator inspected the portion of kiln shell coating that was performed in March 2001. Inspection revealed no noticeable delamination of steel thickness, and much of the coating could still be seen intact (Figure 2).

In June 2004, a different 100 ft. section of internal kiln shell was to be coated. The shell was closer to the burn area, and the coating material was specified to withstand a higher temperature than the material for the upper transition area. Preparation of the steel substrate was the same as with the previous applications. The coating was an inorganic-ceramic, aqueous-based coating, aluminium-ceramic filled, that was applied by spraying two 6 mm wft coats to dry at 3 mm dft per coat, for a total dft of 6 mm. During this outage, the applicator inspected a portion of the 2001 coating, which revealed some of the original 2001 coating still intact. More importantly, the appearance of the steel substrate revealed a smooth surface, and no evidence of delamination. This demonstrated that the coating application created a 'barrier' coating between the internal shell wall and the corrosion contaminates. The coating extended service life to the kiln shell, which would have suffered steel loss without the coating.

Summary

With the available data from the case studies, it is this applicator's recommendation that treating the corrosion attack from the interior portion of the kiln shell has been successful for a number of reasons:

- The media blasting of the interior kiln shell wall removes the chemical debris and contaminants from the shell, which can be the catalyst for the onset of corrosion. Refractors have reported that the media blasting of internal shell leaves a smoother, cleaner surface to work on, thereby saving labour costs and providing a tighter seal for the refractory brick.
- The application of a heat and corrosion resistant lining to the clean substrate creates a sacrificial barrier between the chemical contamination and the shell. This barrier coating slows the corrosion rate to the interior wall.

- Slowing the deterioration rate of corrosion to the thickness of the shell will extend the service life of the equipment, while saving the plant expensive replacement costs and downtime.
- This process of internal kiln shell application can be performed at a fraction of the cost of steel replacement. These applications have been tried and accepted in several plants with positive results, becoming an integral part of their maintenance programmes.

Case study - internal baghouse

In October 2004, Specialized Coating Technology was awarded the interior painting portion of a newly erected kiln mill filter baghouse of over 15 000 $ft.^2$ The challenge of this baghouse was similar to the challenge of the internal kiln – the coating needed to be heat and corrosion resistant, be capable of withstanding temperatures up to 600 ˚F, and be able to last as long as the plant's cycle for changing the baghouse bags (up to five years). An internal coating was applied to the interior in October 2004, and upon inspection in 2009, the applied coating was still intact, with no evidence of density loss.

Application

The contract including coating internal baghouse walls, ceilings, floors, thimbles and hoppers; the steel had been newly erected, and the structural supports were precoated with a separate shop system. At the time the contract was awarded, the plant decided not to recoat the supports with speciality coating (Figure 3).

The solution:

- Find a heat and chemically resistant coating that can tolerate the aggressive environment for an extended period of time - preferably up to five years.
- Perform the preparation and application of coating in conjunction with the plant's scheduled outage safely and efficiently without causing additional delays.

Steel was prepared by grit blasting to SSPC-10, near white blast (0.001 in. profile). A VOC compliant high build silicon and corrosion resistant, self-priming air dry coating was applied at three coats. Each coat was applied at 7 – 8 mm wft, which dried at 4 - 5 mm dft per coat, totalling 13 dft (Figure 4).

In February 2009, the company was called out to inspect the unit. Upon inspection, all coating applied in the 2004 application was still intact, with no appearance of density loss of coating. Signs of corrosion only appeared on the supports that had been precoated offsite by a separate shop system. The plant requested that those supports be blasted and coated during their ongoing February 2009 shutdown with the same speciality coating that had been applied previously in 2004. The applicator blasted and applied three coats of the same material to the same specifications as 2004, and the project was completed within seven days (Figures 5 and 6).

Summary

- The media blasting of the interior baghouse removes the chemical debris and contaminants from the steel. These contaminants can act as a catalyst for the onset of corrosion.
- The application of a heat and corrosion resistant lining to the clean substrate creates a barrier between the contamination and the steel; this slows the deterioration process.
- Inspection of the coating four years after the initial application revealed the coating chosen was successful and was intact with no evidence of deterioration of coating or steel loss. Inspection also revealed that the support structure coating that was precoated offsite prior to erection had suffered extensive deterioration. The owner requested that the applicator supply the same speciality coating that was used in 2004. This inspection demonstrated the differences in paint systems: internal flue gas equipment requires speciality coatings designed to withstand the surrounding corrosive environment.

Case study - flare stack internal coating sample

This case study began in February 2009. The lower 20 ft. of a main exhaust flare stack had what seemed to be a very porous appearance, and had large gaps between plates. Throughout

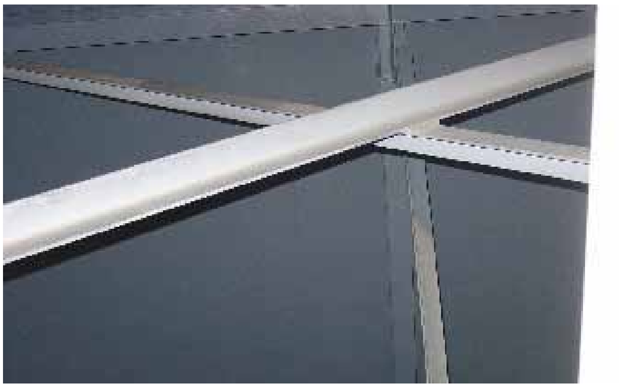

Figure 4. October 2004 - baghouse coating applied (excluding supports).

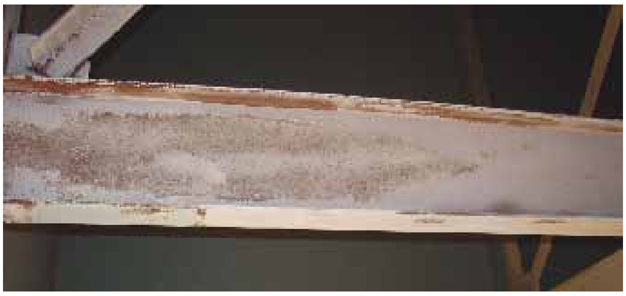

Figure 5. 2009 Inspection of 2004 baghouse coating revealed coating intact, however corrosion attack to supports is evident.

Figure 6. Baghouse coating applied to supports in 2009.

the stack, especially above the transition section, there were areas that had extensive pitting of steel over the years, and although those areas were blasted to white metal blast, the steel continued to appear discoloured, indicating contaminants embedded deep within the shell.

The solution:

- Clean steel to remove as many salts and contaminants as possible.
- Seal the joints between the interior plates.
- Find a heat and chemical resistant coating that can tolerate the aggressive environment.
- Find a heavier durable heat and chemical resistant coating capable of protecting the permeable state of the lower substrate.

Figure 7. Internal stack coating applied in 2009.

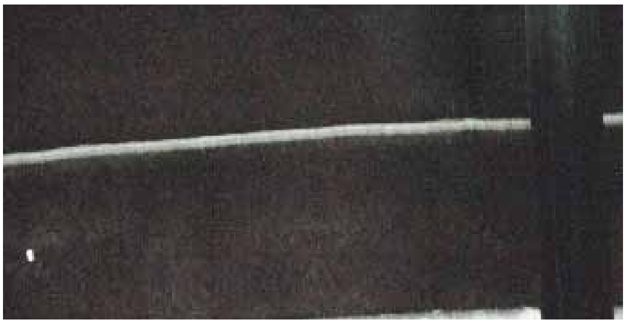

Figure 8. 2010 inspection of flare stack.

Figure 9. August 2009, coating of refractory clip.

In February 2009, a test application of a speciality product was applied to the inside portion of a 24 in. manhole cover. The coating used consists of a Hi-Build Hybrid Epoxy, which includes an amount of Kevlar™ with an additional rubber additive. The steel substrate was grit blasted to SSPC-10, near white blast. The product was applied by spray method for two coats. Each coat was applied at a thickness of 30 - 40 mm, which dried at a total of 65 mm dft. The appearance of this coating is similar to that of a bed liner.

In December 2009, inspection of the sample revealed that the coating was intact and there was no evidence of loss of material, or penetration, or deterioration. At this time, the owner requested that the applicator apply another sample of the product to the lower 20 ft. dia. of the interior portion of the stack shell. Due to the permeable state of the lower internal wall, as well as the open joint gaps between the plates, it was necessary that this steel be cleaned and sealed before the coating was applied to ensure a clean and tight seal. Thickness of the wall here was approximately 0.5 in. plate. The applicator grit blasted the area to SSPC-10, near white blast, and then power washed the area. This was followed by another grit blast to SSPC-10. A heat tolerant calk was applied to the joints for a tighter seal. The coating - the Hi-Build Epoxy Hybrid system with rubber additive - was then applied in two coats. Total dft was approximately 120 - 125 mm or 0.125 in. thickness (Figure 7).

Operating temperature of the stack is between 245 - 250 ˚F, although it occasionally cycles at approximately 350 ˚F. In May 2010, Specialized Coating Technology had the opportunity to perform an inspection. The coating was intact with no evidence of loss or delamination. This coating study is ongoing and will be inspected at the next outage (Figure 8).

Summary

- The extensive cleaning and preparation of the steel substrate to remove embedded chemicals and contaminants was of utmost importance.
- The application of a chemical and heat resistant coating creates a barrier that increases the surface life of the steel and slows the deterioration process.
- In the lower section of the stack, sealing the joints and applying the coating at the 0.125 in. thickness added strength, durability, flexibility and chemical resistance to that section of steel, stopping any further penetration of chemical attack or abrasion of product debris in the unit.

Case study - refractory anchor coating

Refractory anchors are used in refractory brick installations throughout the plant in vertical and horizontal applications. They are used in the installation of refractory brick for kilns and other vessels, and help to hold the brick in place. These anchors are exposed to the same chemical attack that the kiln shell wall is exposed to. They are also exposed to heat and thermal shock. Severe corrosion causes premature brick failure and outages. It is very important to consider the use of a corrosion and heat resistant coating being applied to these refractory anchors.

The solution:

- Find a coating that will protect the anchors from the chemical/heat attack they are exposed to in the cement flue gas industry.
- Provide a cost effective and time efficient manner of coating these anchors either ahead of time before the shutdown, or by providing a low VOC coating that can be sprayed during the shutdowns to follow the refractor in its installations.

Application

In August 2009, Specialized Coating Technology was presented with several refractory anchors and clips, various sizes and shapes. These anchors and clips were new and made of 314 and 310 stainless steel. The surfaces of the clips and anchors were cleaned by hand and using chemicals. Portions of the units were taped off to provide a clean surface for welding. The applicator used two different materials for coating these units; both coatings were compatible with refractory installation materials. The first material was a Hi-Build Novolac-low viscosity epoxy, designed for highly corrosive applications as high as 500 ˚F. The coating was sprayed on at 6 - 7 mm wft (5 - 6 mm dft); total dft was 10 - 12 mm. The second coating used was an inorganic ceramic aqueous-based coating, aluminium filled. This was designed to withstand heat to 1400 - 1500 ˚F, and resistant to thermal shock, oxidation and chemical corrosion. The coating was sprayed on at 4 m wft per coat (2 - 3 mm dft); total dft was 6 mm dft (Figure 9). This coating is being monitored.

Summary

- Stainless steel refractory anchors and clips are not impervious to severe corrosion attack.
- Application of a chemical/heat resistant coating will add service life to this equipment and may aid in the prevention of premature brick outage.
- Precoating these anchors is a relatively simple process. Providing the plant/installer precoated anchors available for use before outages adds the benefit of convenience and time efficiency to the process of installation.

Solutions

Considering the data from these case studies, it appears that confronting the corrosion attack on the interior portions of the kilns, baghouses, flare stacks and other vessels has been successful for a number of reasons, including:

- Cleaning of the steel substrate of this equipment removes chemical debris and contaminants, which act as a catalyst for the onset of the corrosion from the substrate. This is an important step that should not be skipped and no short cuts should be taken.
- The application of the internal coating to the clean substrate creates a sacrificial barrier between the chemical contamination and the clean substrate. The barrier coating adds service life to the internal portion of the equipment by slowing down the rate of deterioration to the steel.
- Extending the service life of the steel with the implementation of internal coatings extends the plant's maintenance budget by reducing their costs.

Conclusion

Field testing and case studies have positively revealed that the use of internal coating applications extends the service life of equipment in a cement plant. Without the use of barrier coatings, surface substrates deteriorate rapidly, leading to premature equipment failure, steel loss and possible safety issues, which result in expensive steel replacement costs and associated unscheduled downtime.

Providing additional service life to steel also provides additional service life to a plant's maintenance budget. In today's economy, it is more important than ever to protect steel and budgets. The costs of the applications of internal coatings are minimal compared to steel replacement and associated costs. The time taken to perform these applications is also minimal compared to replacement costs.

It is the author's belief that the implementation of internal coatings in kilns, baghouses, flare stacks and other flue gas equipment should be included in a cement plant's maintenance budget as a necessary and cost-effective tool.