ALTERNATIVE SOLUTIONS FOR CORROSION PROBLEMS IN CEMENT PLANT POLLUTION CONTROL EQUIPMENT

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ABSTRACT

Corrosion is expensive. This paper focuses on some of the major issues regarding the pathology of corrosion, from formation to mitigation, and finally to prevention and control. In 1999, the U.S. Congress mandated the U.S. Federal Highway Administration (FHWA) to study the direct costs associated with metallic corrosion in many U.S. industries. The two-year study estimated that corrosion impacts this economic sector nearly $276 Billion or nearly three percent of the Gross Domestic Product ($1000/capita).(1) It is an issue in cement plants that is often considered a cost of production. Many methods have been developed in an attempt to prevent and halt metallic losses because of this phenomenon. This paper identifies effective strategies to control corrosion in the cement industry.

INTRODUCTION

Corrosion issues in cement plants are frequent and costly. Some have experienced more corrosion than others and different process areas can be more susceptible to its effects than others. In general, corrosion in cement plants is formed when process gases containing H_2O, SO_x, CO_2, Cl, and NO_x, operate around dew point temperatures. This paper will bring forth practical methods used to prevent corrosion and technology recently developed to control corrosion in the cement plant.

In general, operators attempt to maintain process gas temperatures above the dew point and or remove corrosive gas constituents. Maintaining sufficient gas temperature to avoid condensation on the equipment walls can be expensive and limited by environmental regulations. This approach does not eliminate condensation during start up and shutdown, when temperatures rise and fall through the dew point. Removing corrosive gas constituents is also costly and sometimes not feasible.

The annual costs associated with corrosion per cement kiln baghouse, for example, can be $100,000 to $500,000, depending upon the severity of the problem.(2) Baghouses are not the only problem area. Stacks, ductwork, scrubbers, and other process equipment can all be affected. It is not uncommon to see thirty-thousandths of an inch of corrosion in a single year. The ramifications for this severity of corrosion will ultimately lead to higher operating costs and marginal operations. There are alternatives that can allow plants to operate at lower temperatures, using less expensive fuels and raw materials.

PROBLEM AREAS

In cement kiln systems, a big problem area is the pollution control device. Ductwork entering and exiting the pollution control device and the stack are all candidates for corrosion. Water sprays, used to control temperatures, amplify the problem. A pre-heater process with an in-line raw mill will typically have less corrosion even though the pollution control device operates at a lower temperature and higher humidity. The reason is that the raw mill effectively reduces, “scrubs”, sulfur and chloride compounds that cause corrosion in the cooler areas of the plant. A process with a partial bypass of the raw mill will have more corrosion problems if the mixed gas temperature is around the dew point. Some processes have acid gas scrubbers, which are also problematic if they are not protected. In these systems, the stack would also be a problem area. In general, equipment operating in the cooler end of the process is where most of the corrosion develops. These areas are sensitive to cold air in leakage, low external temperatures, and start-ups and shutdowns.

NEW REGULATIONS IMPACT ON CORROSION

EPA standard, 40 CFR Part 63, effective June 2002, requires lower gas temperatures entering the pollution control device. This may cause corrosion problems in some plants that previously did not have them. This standard was put into place because data shows that dioxin and furan emissions are substantially reduced when the gas temperature is reduced from 260ºC (500ºF) to 180ºC (350ºF). Water sprays are often the most cost-effective way to achieve this. The increase in moisture and decrease in temperature may cause acid condensation on the walls of down stream equipment. After such modifications have been made, plants may face corrosion where it was not an issue in the past.

MATERIALS OF CONSTRUCTION

1. Insulation

Proper insulation and its maintenance can sometimes solve corrosion problems under the right conditions. However, insulated equipment with operating gas temperatures around the dew point can still have significant corrosion. Figure 1 shows the inside of an insulated baghouse that has experienced severe corrosion.

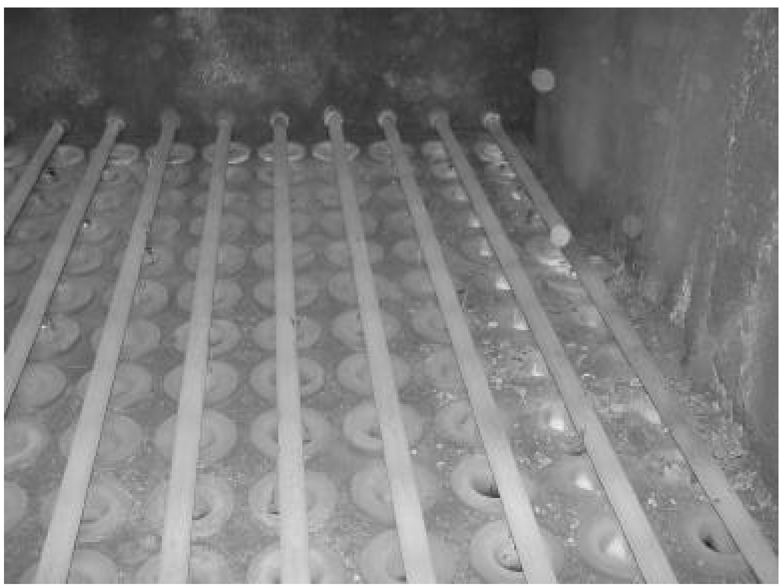

Figure 1
Interior of an Insulated Baghouse

This baghouse operates in a high sulfur environment near the dew point. The walls are corroding and scale is falling on the tube sheet along the walls. There are several strategies that can be used to approach the problem: 1) Modify the process to raise the gas temperatures well above the dew point. 2) "Wall paper" the walls and replace the tube sheet with a suitable corrosion resistant metal. 3) Protect the walls and tube sheet with a suitable coating.

2. Corrosion Resistant Metals

Corrosion resistant alloys have proven effective in various environments. The chemical compositions of a couple of these alloys are listed in Table 1.

Stainless steels are alloys of iron that have a minimum of 11% chromium. More chromium can be added to increase the corrosion resistance. Alloys containing Molybdenum have improved resistance to pitting and crevice corrosion. The addition of nickel provides resistance to reducing environments. When nickel comprises more than 25% of the metal, it improves the stress corrosion cracking resistance.

	Ni	Fe	Mn	C	Si	S	Co	Al	Ti	Cr	Mo	W	V	P	Nb+Ta
Inconel 625	**58 min**	**5.0 max**	**0.5 max**	**0.10 max**	**0.5 max**	**0.015 max**	**1.00 max**	**0.4 max**	**0.4 max**	**20-23**	**8-10**			**0.015 max**	**3.15-4.15**
C-276	**Bal.**	**4-7**	**1.00 max**	**0.01 max**	**.08 max**	**0.03 max**	**2.50 max**			**14.50-16.50**	**15.00-17.00**	**3.00-4.50**	**0.35 max**	**0.04 max**	

Table 1
Corrosion Resistant Metal Compositions

If process gas temperatures operate above 300ºC (570ºF), then these materials are frequently a solution to corrosion. Equipment, ductwork, and stacks fabricated of these alloys, however, are very expensive.

A more economical solution is metal cladding. Metal cladding can save up to 80% of the cost of using a solid alloy for construction. Cladding metals are chosen for their corrosion resistant properties, and sometimes for their ability to be anodic to the core metal. If the cladding material is damaged, then the cladding can provide cathodic protection by corroding sacrificially. "Roll bonding", explosive bonding, weld overlaying, and "wall papering" are methods of cladding which have been available for over forty years. Roll bonding of materials like Inconel and C-276 to a structural material such as A-36 (plain carbon steel) can be a good method of protection. Roll bonding is the most widely used method to fabricate clad metal plate. Explosive bonding utilizes a high-energy charge to join metals. "Wall papering", with thin sheets of corrosion resistant metals, edge welded to the base metal, can be used to protect equipment that was not expected to be in a corrosive environment, but is. Weld overlaying is a process of cladding that can be used on existing structures. This process involves welding sheets using a high alloy weld material.

Proper understanding of process variables, raw materials, and fuels is key to determining what type of materials to use to prevent corrosion. Problems may arise when raw material, fuels, and temperatures are not as expected. Examples are alternative fuel utilization, raw material substitution, or changing to high sulfur coal or petroleum coke.

3. Conventional Protective Coatings

Many coatings have been developed in the past. Epoxy based coating materials can resist the effects of acid condensation to some degree. Acrylics, alkyds, or polyesters will not withstand normal operating temperatures.

The failure modes for these types of coatings are oxidative degradation or delamination. Oxidation damage occurs when the process equipment operates above 150ºC (300ºF). Undercut corrosion, dis-bonding and delamination happen when there is any surface damage or imperfection in the surface preparation. Figure 2 illustrates a typical failure mode of an epoxy coating on a baghouse door after being exposed to excessive temperatures.

4. New Corrosion Protection Technology

Tests have shown that a new polymer-based coating can withstand continuous temperatures of 225ºC (440ºF), and spikes up to 300ºC (570ºF). The material develops a strong bond to the steel substrate and resists undercut corrosion. Figure 3 shows this coating's resistance to undercut corrosion in a very severe environment. The test plate was in service for five months in a baghouse where the corrosion rate had drastically increased due to the use of high sulfur coal. Note that the corrosion stops right at the border of the coating. There is no observable undercut corrosion.

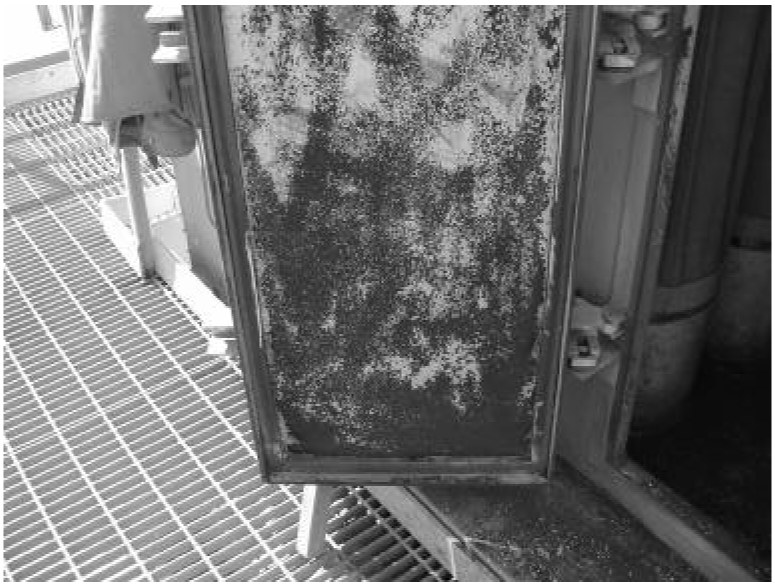

Figure 2
Failed Epoxy Coating

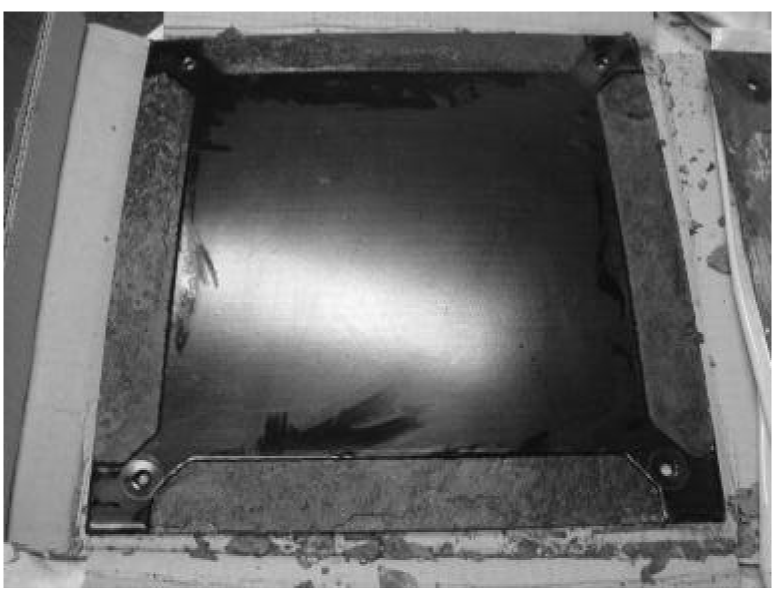

Figure 3

Resistance to Undercut Corrosion

This hybrid polymer-based coating technology seems to be a revolutionary solution to corrosion protection in cool end equipment. Research and development is further increasing the limits on operating temperatures. The coating can be applied during original fabrication as well as after the equipment is in operation, when actual conditions indicate excessive corrosion. All coatings are not created equal. Because one coating has failed, does not mean all will fail. Keys to successful coating application are proper surface preparation, proper application technique, and proper curing, and all performed with a qualified installer. Figure 4 shows the tube sheet of a baghouse coated with the polymer-based coating. After one year in service, there is no corrosion, while the galvanized blowpipes and cages show severe damage.

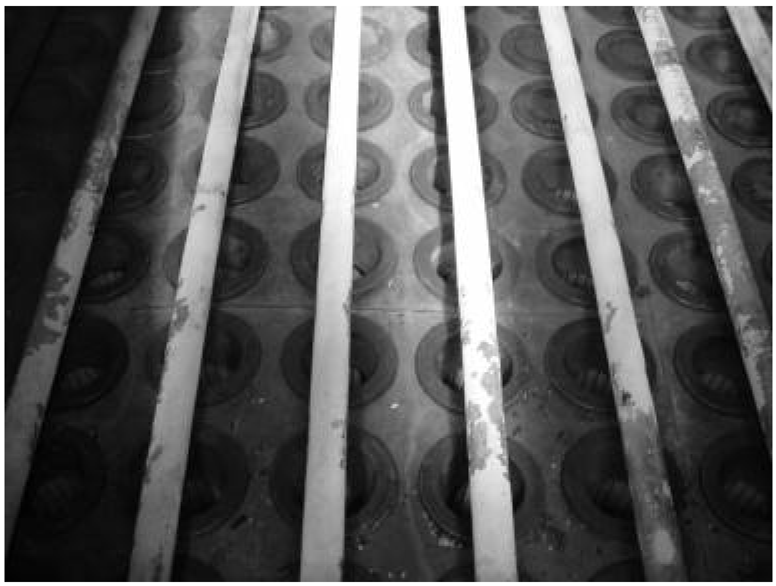

Figure 4
Tube Sheet Protected with a Polymer Based Coating,
Galvanized Blow Pipes and Cages Corroding

CONCLUSION

There are solutions to corrosion. Corrosion issues in the plant may require different controls. In most cases the solution comes with a price. If nothing is done, corrosion will cost in maintenance, down time, and efficiency. If the wrong solution is chosen, it will again cost in maintenance, down time, and efficiency. Recognizing the short and long term economic impact of corrosion can rationalize the capital investment when selecting a cost effective corrosion control solution. Understanding operating parameters and then determining suitable corrosion prevention methods effects front end capital costs, but will be far less than the subsequent maintenance, lost production, and cost to run inefficient equipment. Whether in new plants, plant expansions, or modifications, the need for corrosion prevention must be evaluated. Some time and money up front will save a lot of time, production, and money over the operating life of the equipment. Corrosion, when understood, can be controlled with cost effective solutions.

REFERENCES

(1) NACE International, “News Release”, August 15, 2002

(2) IEEE-IAS/PCA Conference Record, Vancouver 2001, “Strategies for reducing Cement Kiln Baghouse corrosion problems”, Neal W. Biege.