HOW TO FIX SEVERE CORROSION CAUSED BY ACID GASES

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Summary

Corrosion is the destructive attack of a metal by reaction with its environment. The serious consequences of the corrosion process have become a problem of worldwide significance. Corrosion causes plant shutdowns, waste of valuable resources, loss or contamination of product, reduction in efficiency, costly maintenance, expensive over design also can jeopardize safety. Corrosion is expensive and is a major issue in steel plants that is often considered a cost of production. Many methods have been developed in an attempt to prevent and stop metal losses. This paper will focus on some major issues regarding corrosion caused by acid gases, from formation to mitigation, and finally to prevention and control.

Key-words: Corrosion process; Corrosion control; New technologies; Cost effective solutions.

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INTRODUCTION

The type of corrosion mechanism and its rate of attack depend on the nature of the atmosphere in which the corrosion takes place. The first step in preventing corrosion is understanding its specific mechanism. The second and often more difficult step is designing a type of protection mechanism. Successful enterprises cannot tolerate major corrosion failures, especially those involving personal injuries, fatalities, unscheduled shutdowns and environmental contamination

Typically, once a plant or any piece of equipment is put into service, maintenance is required to keep it operating safely and efficiently. This is particularly true for aging systems and structures, many of which may operate beyond the original design life.

Corrosion issues in steel plants are frequent and costly. Some have experienced more corrosion than others and some process areas can be more susceptible to its effects than others. In general, corrosion in steel plants occurs when process gases containing moisture, SOx, CO2, Cl, and NOx, operate around dew point temperatures. This paper will bring forth practical methods used to prevent corrosion and technology recently developed to control corrosion in a steel plant.

Corrosion Process

Carbon steel and even stainless steel corrodes in flue gas service. Equipment like electrostatic precipitators, bag houses, cooling ducts, conditioning towers and stacks frequently fail due to corrosion.

Corrosion is worse when there is a presence of acidic compounds in the flue gas. The source can be from sulfur content in the feed or the fuel, chloride content in the feed or in air and CO2 and NOx from combustion. The moisture content in the gas produces hot acid condensation on the steel walls, in most cases intermittent for short periods of time, the cumulative impact can be up to 1.0 mm/yr, meaning less than 5 years life.

Air pollution control devices, the fans and the stack are all candidates for corrosion. Water spray cooling towers used to control temperatures, amplify the problem. 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 startups and shutdowns.

Corrosion Control

There are different ways to reduce the corrosion impact. Adjusting the operating conditions, for example higher temperature to avoid condensation. This is not always possible and is a substantial waste of energy. Different materials of construction, like the use of 316L or higher alloys leads to 3 to 5 times capital investment and involves the risk of stress corrosion cracking.

Traditional coatings require a surface preparation that is expensive and critical and usually have a limited useful life due to blistering and delamination.

In many cases 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 costly and sometimes not feasible.

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. 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.

Figure 1. Severe corrosion damage in a reverse air bag house filter.

2. Corrosion Resistant Metals

Stainless steels are alloys of iron that generally have a minimum of 12% 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.

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. 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.

Figure 2. Catastrophic failure of a high temperature coating.

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 a high temperature epoxy coating on a baghouse after being exposed to high temperature condensing acid.

New Material Technologies

There are new coating technologies available, one is a hybrid organic-inorganic polymeric alloy material, suitable for continuous operation up to 225ºC (437ºF) that can handle peaks for several hours up to 300ºC (572ºF). This material, known as FlueGard-225, has a tenacious bonding to steel and very good resistance to hot acids and abrasion.

Figure 3. Inspection of FlueGard-225 after 2 years in a bag house filter. No corrosion.

The first successful applications were made more than 4 years ago with numerous installations to date in baghouses, precipitators, fans, stacks and ducts. There are currently many ongoing projects in different industries like cement, oil refining, power generation, steel mills, metal smelting, lime, waste incineration, carbon black and battery recycling. Figure 3 shows the effectiveness of this corrosion protection system in a bag hose filter after more than 2 years in service.

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. A successful coating application requires proper surface preparation, proper application technique, and proper curing, and all performed with a qualified installer. Figure 3 shows a baghouse coated with the polymer alloy coating. After two years in service, there is no corrosion.

Other Problem Areas

In steel mill systems, a big corrosion problem area is the cooling ductwork that collects the gases from the furnace. Here the gases can be in the 900 to 500ºC range, and the wall of the water cooled duct can be in the 100 to 300ºC. Figure 4 illustrates the severe corrosion occurring in one of these ducts.

Figure 4. Severe corrosion of the cooling duct in a steel mill.

Recent Material Development.
There is a very recent material developed to address the corrosion problems at very high temperatures. This new system is a combination of an inorganic polymer binder and two reactive inorganic fillers that have particle sizes in the nanometer range. The available surface of these fillers is about one million times larger that conventional materials and the end result is a corrosion protection coating that works well at 325ºC and resists exposures up to 700ºC. Figure 5 shows a steel panel coated with this material called FlueGard-325. The first successful application is on the gas side of the 2" finned tubes of a new economizer in a waste to energy plant.

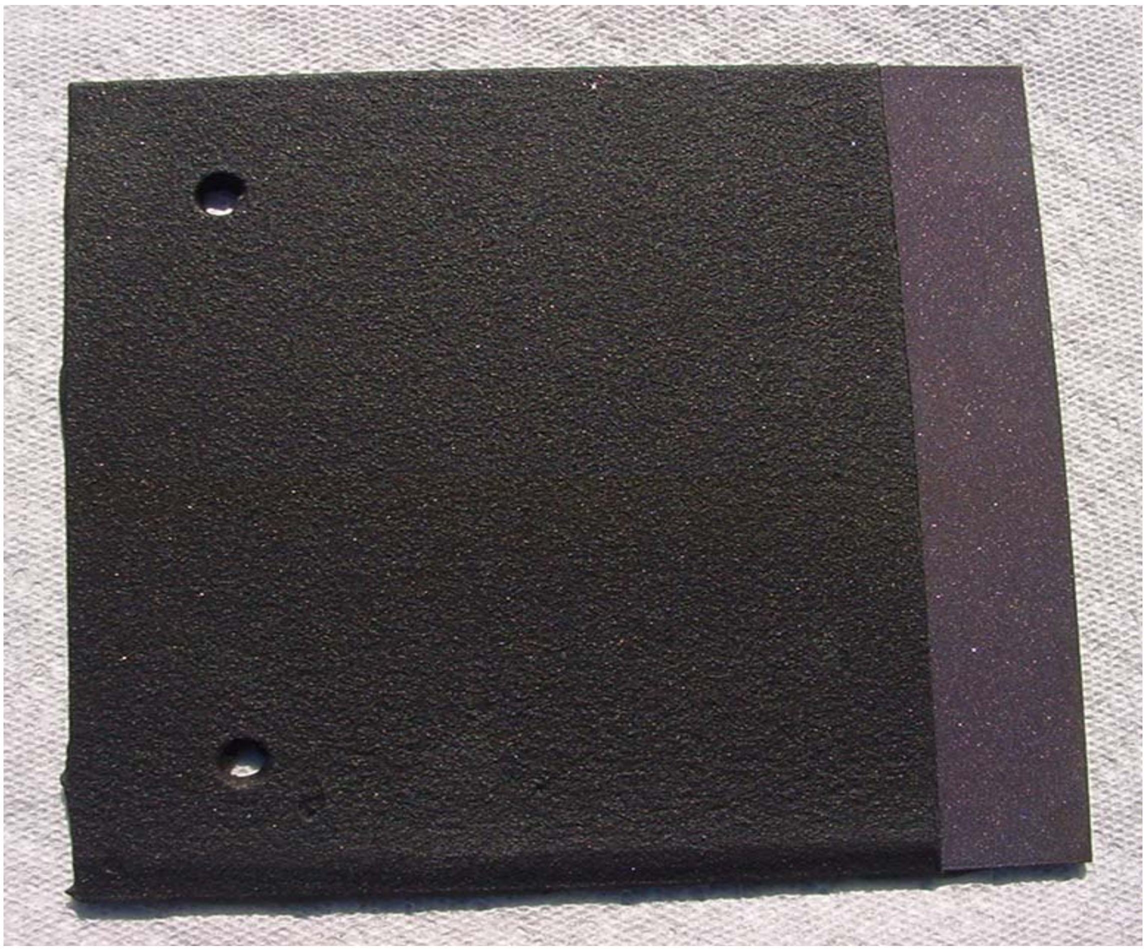

Figure 5. Steel plate coated with FlueGard-325 and cured at 250ºC

CONCLUSION

There are solutions to corrosion. Different 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. A good understanding of the operating conditions and then determining suitable corrosion prevention methods increases the 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.

COMO SOLUCIONAR O PROBLEMA DA CORROSÃO SEVERA PROVOCADA POR GASES ÁCIDOS

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Resumo

Corrosão é o ataque destrutivo do metal causado pela sua reação com o ambiente em que se encontra. As graves conseqüências do processo corrosivo tornaram-se um problema de significância mundial. A corrosão causa paradas, desperdício de recursos valiosos, perda ou contaminação de produtos, redução de eficiência, manutenção dispendiosa e designs superdimensionados são dispendiosos e podem também por em risco a segurança. A corrosão é dispendiosa e é assunto vital na indústria siderúrgica, sendo muitas vezes incorporado como um custo de produção. Muitos métodos já foram desenvolvidos na tentativa de prevenir e acabar com as perdas de metal. O presente estudo focará os temas de maior relevância no que diz respeito à corrosão causada por gases ácidos, de sua formação à sua mitigação e, finalmente, à sua prevenção e controle, apresentando uma linha de produtos totalmente inovadora fabricados pela 3L&T - um destes produtos de liga polimérica híbrida orgânica-inorgânica, própria para uso em temperaturas até 225ºC, que reage quimicamente com a superfície metálica do aço e outra de liga polimérica inorgânica que suporta temperaturas até 325ºC constantes e picos de 700ºC.

Palavras-chave: Processo corrosivo; Controle da corrosão; Novas tecnologias; Soluções sustentáveis economicamente.