Polymer lining mitigates corrosion of Alloy 2205 in flue gas desulfurization units

A typical FGD unit. Photo courtesy of Sauereisen.

Sulfur dioxide (SO$_2$) is a highly reactive, toxic gas that is linked with a number of adverse effects on human health and the environment, and is a major contributor to acid rain. According to the U.S. Environmental Protection Agency (EPA), combustion of fossil fuels at power plants accounts for 73% of total SO$_2$ emissions. The Electric Power Research Institute (EPRI) reports that most large coal-fired power plants, in response to strengthened National Ambient Air Quality Standards (NAAQS) for SO$_2$ emissions set by the EPA in recent years, have installed state-of-the-art flue gas desulfurization (FGD) technologies to remove the SO$_2$ from the flue gas exhausted when coal is burned. Since 2004, many FGD components, such as absorber vessels, spray towers, tanks, and piping, have been constructed of duplex stainless steel Alloy 2205 (UNS S32205/31803) because of cost and other factors. The vessel, it is sprayed with the alkaline slurry, which reacts with the SO$_2$ and forms carbon dioxide (CO$_2$), water, and precipitates such as calcium sulfate (CaSO$_4$) and magnesium sulfite (MgSO$_3$). The resulting liquid environment in the absorber also contains sulfuric acid (H$_2$SO$_4$) and hydrochloric acid (HCl). Johnson notes that the combination of the slurry’s low pH, the presence of acids, and higher temperatures creates a very corrosive environment for metals.

Alloy 2205, which contains 21-23% chromium, 4.5-6.5% nickel, and 2.5-3.5% molybdenum, is a high-strength alloy designed for improved resistance to corrosion, stress corrosion cracking (SCC), pitting, sulfide stress cracking (SSC), and crevice corrosion in chloride environments, and is used in heat exchangers and pressure vessels. Its selection for use in FGD units was influenced by laboratory test results and early studies in the field that indicated it had good corrosion resistance when exposed to the environmental condi-

A power plant’s FGD scrubber module shows signs of corrosion. Photo courtesy of Sauereisen.
tions in a FGD scrubber—temperatures of 180 °F (54 °C), pH between 5.5 and 6.5, and chloride levels up to 10,000 ppm.3

Industry, however, has reported widespread corrosion of the alloy in FGD units in the form of pitting, crevice corrosion, and SCC, with through-wall penetration observed in some vessels that were in service for less than a year, says NACE member Lake Barrett, sales manager with specialty coating manufacturer Saureisen, Inc. (Pittsburgh, Pennsylvania) and a NACE-certified Level 3 Coating Inspector. The cause of the corrosion is still under investigation, but is believed to be a result of acid condensates forming during the scrubbing process and the creation of scale on the walls of the absorber vessel from precipitates that accelerated pitting and crevice corrosion, particularly in scrubbers with high concentrations of sulfates and chlorides.

“The precipitates cling to the absorber wall and electrochemical corrosion cells form in the underlying metal,” Johnson explains. The corrosion varies from one system to another and is dependent on environmental factors such as gas velocity, acidity, dew point, temperature, wet-dry cycles, and chloride and fluoride concentrations. Results of an EPRI study indicate that factors contributing to the corrosion include a shift from natural and inhibited oxidation systems to forced oxidation systems, which led to an increased likelihood of scale forming on the absorber walls.3

Barrett comments that many power plant operators have chosen to rehabilitate the corroded interior walls of FGD absorber units with protective linings comprising novolac epoxy vinyl ester resins and glass flake or glass fiber, which will protect the underlying metal from further corrosion. These linings are specially designed to with-stand the low pH, aqueous chloride environment found in FGD absorbers. He adds that the resins are resistant to higher temperatures, H₂SO₄ and HCl, as well as high concentrations of chlorides, and are frequently used in much more aggressive chlorine environments with HCl and sodium hypochlorite (NaClO). These linings incorporate the same epoxy vinyl ester resin technology used in FGD vessels constructed of fiber-reinforced polymer (FRP), which have been perform-

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This includes the composition of the liquid and gaseous materials, maximum temperatures, temperature cycling, and abrasive material flow. For the FGD absorber, a novolac modified resin was selected over the Bisphenol A (BPA) resin due to its ability to withstand higher temperatures and more severe chemicals. To determine the performance of the resins in the FGD environment, the polymer was evaluated in the lab and tested in the field, Johnson notes.

Before a lining is installed, the surface of the vessel is prepared. This typically includes abrasive blasting to NACE No. 2/SSPC-SP 10 with an aggressive profile of 3 to 4 mils (76 to 102 μm), and repairing any corrosion damage. Once abrasive blasting is complete, the surface must be checked for chlorides and other contaminants that must be removed. Rehabilitated absorbers may have severely pitted surfaces that need to be filled with a material compatible with the protective novolac epoxy vinyl ester lining. New absorbers constructed of Alloy 2205 also can be lined so future corrosion is minimized.

The linings are normally applied with airless spray equipment, although the traditional hand-laid trowel application method can still be used. Typically the thickness of the lining system is based on the specific environment in the FGD absorber and can be anywhere from 60-mils (1.5-mm) thick, for less aggressive environments, up to 375-mils (9.5-mm) thick, which includes heavy-duty fiberglass-reinforced mortar mat for more aggressive environments.

Novolac epoxy vinyl ester lining systems installed on rehabilitated Alloy 2205 FGD absorbers have been in use for several years now and have an expected service life of 10 or more years with regular maintenance.

This article is based on CORROSION 2013 conference paper no. 2105, “Epoxy Vinyl Ester Polymer Lining for Duplex UNS S32205/S31803 Alloy FGD Absorber Modules,” by I.M. Ramsey, T.L. Johnson, and D.H. Kelley.

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