

Flue Gas Desulfurization Systems: **Using Protective Coatings to Reduce Energy Demands**

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INTRODUCTION

Flue Gas Desulfurization (FGD) plants are sometimes referred to as “a chemical process plant attached to a coal-fired fossil power plant.” In some regards this is true since FGD systems involve temperature swings from ambient up to 350°F, corrosive gases and their condensates, and abrasive wear in the form of dry solids and slurries—all occurring in the support of the neutralization and gas cleaning processes. The subsequent corrosion and abrasion can severely degrade equipment and result in costly downtime and repairs. A secondary impact is increased operational costs such as electrical energy associated with reagent preparation and slurry pumping.

In this e-book we'll explore how FGD assets can be protected with advanced surface enhancement coating technologies and how this effort can increase plant equipment reliability as well as the overall energy efficiency of the entire flue gas desulfurization plant.



WHAT YOU WILL LEARN

- How system operating conditions exert varying stresses on different coating options
- How various coatings function to provide the required protection
- Which product technologies are better suited than others in specific process areas
- How new protective coatings technologies can reduce maintenance costs and, in select instances, reduce operational (energy) costs of high energy equipment such as pumps, mixers, screws, and fans driven by electric motors

Key Benefits of Using Coatings on Flue Gas Desulfurization Equipment

- 1 Reduced energy consumption and maintenance:** More efficient operation of pumps, agitators, and fans
Example: Slurry recirculation pumps, which experience severe damage from corrosion and abrasion, can be quickly and efficiently rebuilt and protected from further attack
- 2 Lower costs:** Coatings allow the use of conventional carbon steel surfaces which can be upgraded to reduce corrosion and abrasion attack, rather than requiring exotic alloys
Example: Super duplex agitators can be fabricated from carbon steel and coated with abrasion- and corrosion-resistant ceramic reinforced epoxies at a fraction of the cost of super duplex without any compromise in performance or functionality
- 3 Longer equipment life:** Applied early, coatings protect equipment from early decay and breakdown
Example: FRP spray header pipes upgraded with ceramic reinforced epoxies extend unlined FRP life by a factor of 5X
- 4 Increased safety:** Reduction of hot work permits and fire watches associated with corrosion protection
Example: Reliance on weld repairs for corroded metal can be reduced by incorporating a rigorous protective coatings program with 100% solids, low VOC coatings

The importance of maintenance associated with limestone FGD systems is clear; however the various approaches can vary significantly. “[The Importance of Maintenance for Lime Flue Gas Desulfurization Systems](#),” a report issued by Stone and Webster Engineering over 30 years ago is still relevant and helpful to consider when evaluating priorities and options.

WHAT IS THE ENERGY DEMAND FOR OPERATING AN FGD SYSTEM?



A power plant's output is based on generator capacity. However, the nameplate capacity on the generator is never what the plant puts out to the grid even when it is operating at one hundred percent. According to the [International Energy Association](#), a typical conventional coal-fired power plant operates between 30–40% efficiency. Why is this?

The output differential is due to passive and active energy losses within the plant itself:

- **Passive losses** are attributed to things like steam losses due to leaks.
- **Active losses** are plant equipment energy demands such as pumps, fans, conveyance systems, compressors, etc. Behind much of this equipment are electric motors.

Case in Point: Base Case Plant Study

A 2012 study by Carnegie Mellon University entitled “[Energy Requirements of a Limestone FGD System](#)” focused on a “base case” plant and showed just how much an FGD system can consume of the total energy output:

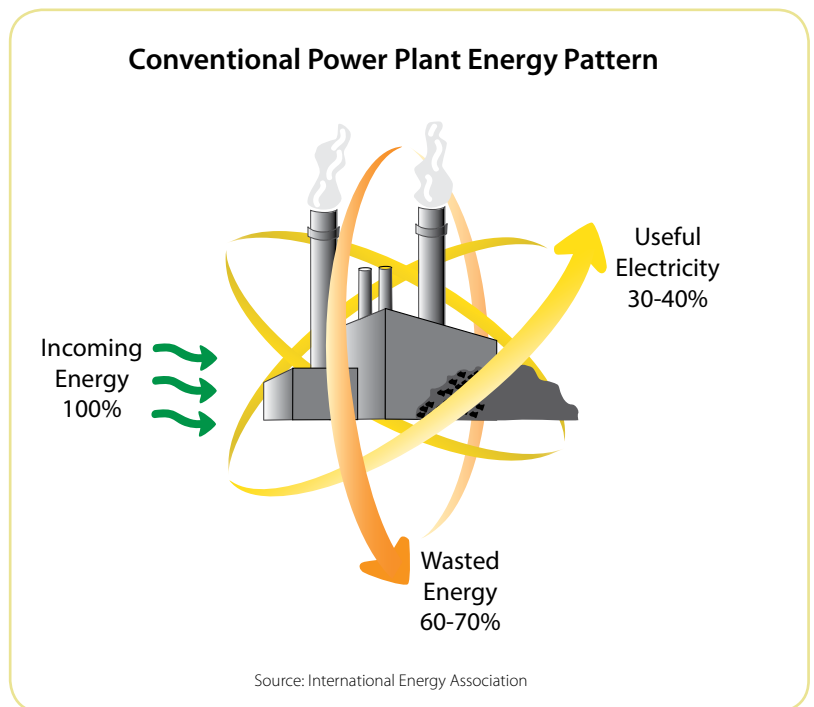
- The 500 MW plant was burning 3.5% sulfur coal
- It had a scrubber system that met the federal new source performance standard of 1.2 lb SO₂/10⁶ Btu
- The flue gas was cleaned by an electrostatic precipitator
- That process was followed by a limestone FGD system with a turbulent contact absorber scrubbing vessel and an optimized, in-line steam re-heater

Because of all this technology, the FGD system was consuming 3.4% of the total energy input to the boiler as measured by fuel Btu.

The primary contributing factors behind this cost were associated with:

- The pH swings in the scrubbing liquid that required the operation of additional high capacity pumps and agitators to maintain added flow of alkaline slurry
- The reheat systems required to achieve plume rise and maintain sufficient temperature to stay above acid condensate dew points of “scrubbed gas”

Other less costly factors impacting energy consumption were materials handling (limestone slurry preparation) and sludge disposal.



THE IMPACT OF AGGRESSIVE CONDITIONS

The equipment used in these processes are exposed to extremely aggressive conditions and requires extended outages to perform necessary maintenance. The actual performance of the FGD plant compared to its design and “as-commissioned” performance is crucial.

As equipment wears, fouls, corrodes, distorts and leaks, as sensors and instrumentation fail, and as calibrations drift, the FGD plant tends to become less efficient. As well as ensuring integrity, a key requirement of plant maintenance is to maintain peak efficiency. Adoption of new and improved maintenance technologies can reduce energy losses.

UPGRADING FOR EFFICIENCY GAINS

Plant maintenance and overhaul activities represent an opportunity to retrofit equipment with more modern components for improved performance. A combination of performance restoration and plant modernization can lead to substantial improvements in efficiency and often to greater generating capacity.

In practice, any poorly performing auxiliary equipment or individual components (such as fans, pumps, heat exchangers, vent and isolation valves, gearboxes, leaking flanges and even missing or inadequate insulation) contribute to the overall deterioration of plant performance over time, compounding the effects of deterioration in major components such as the steam turbine.

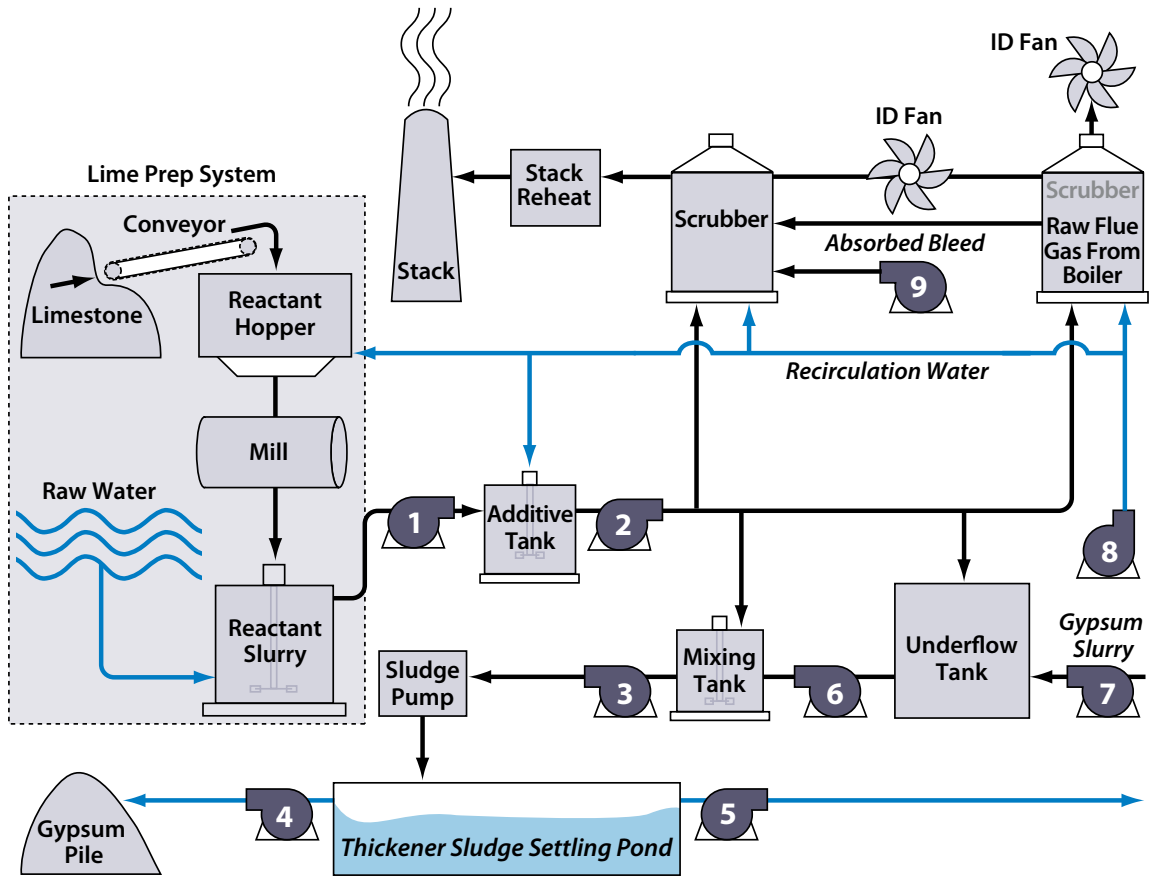
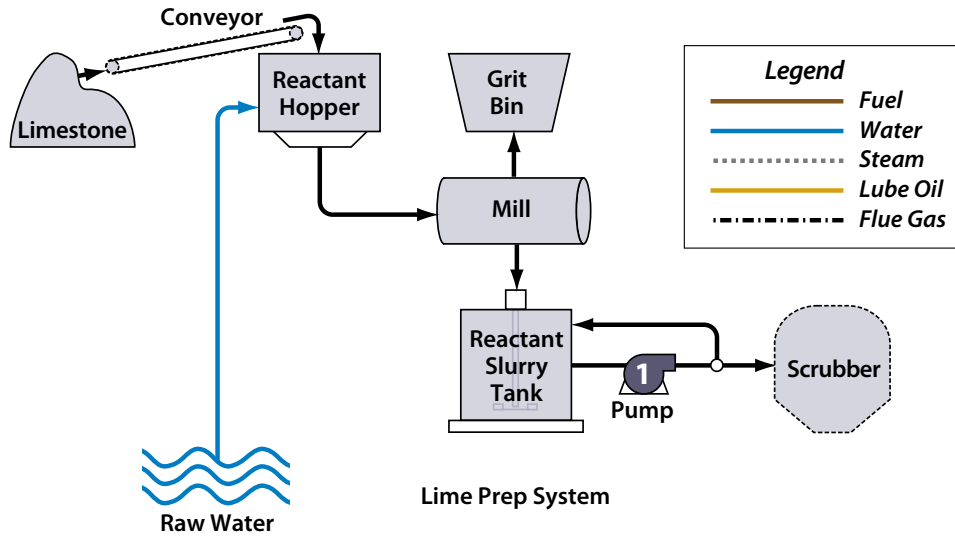
ISSUES IMPACTING A FGD PLANT’S EFFICIENCY

Wet FGD systems comprise nearly 85% of the installed base in the United States. A wet FGD system requires equipment for:

- Preparation of a neutralizing spray solution
- Circulating systems (pumps and piping) for neutralizing solutions as well as raw and clean gases
- Reaction towers (absorbers/scrubbers) where the raw flue gases are neutralized
- Reaction tanks where the precipitates are collected and removed
- Agitation to maintain suspended solids in suspension and to promote oxidation reactions in reaction tanks
- Associated downstream support systems such as solids thickening, separation, and dewatering are required to handle waste by-products



Wet Scrubber System



GENERAL CONDITIONS EXISTING IN FGD PROCESS AREAS

Each of these equipment areas is continually being attacked by the aggressive nature of the flue gas desulfurization process:

- Hot raw gas enters the absorber from the fly ash collection system, where it rises up within the tower by convection
- An alkali slurry is pumped to the top of the tower, where it is atomized and sprayed, counter-current to the gas flow, into the rising raw flue gas
- The alkaline slurry reacts with the flue gas, typically comprised of CO₂, CO, O₂, NO_x, SO₂, N₂, and H₂O, neutralizing the SO₂
- The “cleaned/scrubbed” gas then passes through demisters to reduce wet carryover where it then passes through a series of ducts to a chimney where it exits to the atmosphere primarily as water vapor



The operation of pumps, fans, agitators and materials handling equipment associated with the FGD process have significant energy and maintenance requirements to maintain operational efficiencies.

Flue Gas Desulfurization Systems Table							
Operational Concerns by Process Area							
This table defines general operating conditions within critical FGD systems							
Process Area	Equipment	Temp. Range (°F)	Thermal Cycling (Y/N)	Immersion (Y/N)	Dry Abrasion (Y/N)	Slurry Abrasion (Y/N)	Condensing Gas (Y/N)
Raw Gas	Raw Gas Duct	350–400	N	N	Y	N	N
	Breeching Duct	300–350	Y	N	Y	N	Y
Absorber	Breeching Zone	300–350	Y	N	Y	N	Y
	Reaction Tank	120–140	N	Y	N	Y	N
	Extraction Pumps	120–140	N	Y	N	Y	N
	Recirculation Pumps	110–130	N	Y	N	Y	N
	Recirculation Pipe	110–130	N	Y	N	Y	N
	Spray Zone	120–150	N	N	N	Y	Y
	Mixing Zone	120–150	N	N	N	Y	Y
	Demister	110–140	N	N	N	Y	Y
Exhaust	Outlet Duct	120–130	N	N	Y	N	Y
	Dampers/ Turning Vanes	120–130	N	N	Y	N	Y
	Reheat Zone	160–180	Y	N	N	N	Y
	Breeching Duct	120–180	Y	N	N	N	Y
Chimney	Breeching	120–180	Y	N	N	N	Y
	Liner	120–180	Y	N	N	N	Y
Slurry Prep	Silo	0–110	N	N	Y	N	N
	Chute	0–110	N	N	Y	N	N
	Feeder	50–100	N	N	Y	N	N
	Mill	50–100	N	N	Y	N	N
	Mix Tank	50–100	N	Y	N	Y	N
	Holding Tank	50–100	N	Y	N	Y	N
Waste	Extraction Pump	110–130	N	Y	N	Y	N
	Extraction Pipe	110–130	N	Y	N	Y	N
	Thickener/ Holding Tank	50–100	N	Y	N	Y	N

PROTECTIVE COATING OPTIONS BY PROCESS AREA

Protective coatings have several attractive characteristics that make them viable solutions for corrosion in FGD systems. They can:

- 1 Be formulated for resistance to a wide range pH and chemical species
- 2 Be reinforced with functional fillers/reinforcements that can provide excellent resistance to permeation and abrasion
- 3 Handle temperatures as high as 400°F with thermal cycling conditions present
- 4 Be applied relatively quickly and inexpensively compared to other more time-consuming options such as rubber lining, acid brick lining or metal cladding

When choosing a coating technology, it is important to understand the operational environments within each area for proper product selection. Each process area has its own unique parameters.

RAW GAS HANDLING SYSTEMS

Raw gas handling systems are subjected to high volumes of elevated temperature gas flow with raw chemically-laden flue gases, both with and without particulates in the form of fly ash carry-over.

***Solution:** Normally glass flake/mat reinforced novolac vinyl ester-based chemistries are used here due to their high temperature capabilities; however thermal shock can present problems in quench regions. For this reason, many plants have converted to more corrosion-resistant alloys such as Hastalloy® C22.*

ABSORBERS

Absorbers are at the heart of the FGD system. This is where the neutralization process occurs. Equipment here is subject to wide temperature ranges, corrosive immersion and condensing solutions; and slurry abrasion conditions.

***Solution:** In this area, novolac epoxy and novolac vinyl ester systems may be reinforced with ceramic, glass flake or a combination of both.*

In spray and mixing regions in the absorber (as well as in the slurry recirculation pumps) abrasion and impact may be severe.

***Solution:** Between the spray zone and top of the demister, chemical/abrasion resistance and temperature profiles are less severe so conventional Bisphenol A/F and polyester-based epoxies may be used.*

Slurry Agitator Case Study

An FGD plant experienced severe corrosion and abrasion on their slurry agitators in the recirculation tank below the absorber. Without efficient operation of the agitators, excessive gypsum carryover would precipitate out onto demisters and outlet ducting.

The surfaces of super duplex steel blades were upgraded with ceramic-reinforced epoxy technology. This step maintained operational performance and extended MTBF (Mean Time Between Failure) by 300%.



Plastic Spray Header Pipes Case Study

A large A&E firm was responsible for design and erection of an absorber in eastern Europe, they selected ceramic-reinforced epoxies to coat the outside surfaces of fiber-reinforced plastic spray header pipes to protect them against abrasion attack.

Previously unprotected pipes lasted less than 18 months before wearing through, reducing reagent flow. The ceramic-reinforced epoxy protected pipes last more than 48 months and can be easily repaired "in situ".



EXHAUST GAS DUCTS

Exhaust gas ducts carry saturated clean gas with high humidity. Because condensing gases can form on the floors and the lower sections of walls leading to severe chemical attack, it is important to provide corrosion resistance and permeation resistance.

***Solution:** Coatings with flake-reinforced epoxies and polyesters are commonly used. Turning vanes and damper blades are some specific areas where abrasion may occur. These would require a ceramic-reinforced coating system. If a bypass system or ambient reheat system is used to provide added convection to the gas flow so it can make it out of the top of the stack, then thermal cycling may be present. In this event, a novolac vinyl ester coating system is preferred.*

The chimney accepts the stack gas. Here abrasion is minimal, but the risk of gases dropping down below dew point leading to condensing environments requires the use of flake-reinforced novolac vinyl ester, vinyl esters, and epoxy/polyester coating systems.

Absorber Outlet Duct Case Study

A 100% solids epoxy lining spray applied to absorber outlet ducting has been in service for 7+ years.

Photo on far-right shows the performance and ease with which scale carryover can be removed.



LIMESTONE SLURRY PREPARATION

The limestone slurry preparation area involves both dry and wet slurry abrasion with impact and mild corrosion. In these areas, ceramic-reinforced epoxies of the Bisphenol A/F family are suitable for use. In high impact areas, more flexible systems are required that can handle the impact and abrasive wear.

Limestone Slurry Preparation Case Study

Abraded slurry transport pumps reduced operational flow to absorbers, requiring additional pumps to be brought to the front line.

After rebuilding worn wet surfaces, the extra pumps were taken out of service as design flow was returned.



WASTE HANDLING

The waste handling process involves extracting contaminated reagent water and removing solids for disposal, while returning the liquid phase back into the recirculation water loop. These areas are exposed to immersion conditions in alkaline slurries at moderate temperatures with highly abrasive solids present.

Solution: *In these areas ceramic reinforced Bisphenol A/F epoxy coatings are acceptable.*

Waste Handling Case Study

Centrifuges are used to dewater gypsum by product before sludge disposal. They can be protected effectively with ceramic-reinforced epoxy coatings.



SUMMARY

Maintaining process equipment and structures that are exposed to the flue gas desulfurization environment is critical to ensure that the plant operates within its emissions limits. When measured pH levels in the absorber recirculation system drop due to inadequate flue gas neutralization, additional high pH scrubbing liquid needs to be produced and pumped into the circulating loop. Since all this activity draws upon even more energy, it is clearly in the plant's best interest to take any steps possible to maintain process equipment and supporting structures or return to operational design performance limits.

Since FGD systems can be considered a 100% parasitic load on a plant's output capacity, using appropriate corrosion and abrasion protection materials and methods to extend equipment life and maintain maximum operation efficiency can result in lower FGD equipment operational and maintenance costs.

If you have a specific coatings application question, read more about [Chesterton coatings for the fossil power industry](#) or contact our [Ask the Expert](#) application engineering team.

FOR MORE INFORMATION

[Measuring and Reporting Efficiency Performance and CO₂ Emissions](#)

