Fiberglass Reinforced Polymer Composites for Coal Fired Power Plant SO$_2$ Scrubbers

Ben R. Bogner, P.E.
AOC, L.L.C.
Outline

- Introduction to AOC
- Coal fired power plants & the need for Sulfur Dioxide (SO₂) cleanup
- Brief review of chemistry of sulfur dioxide generation & removal
- Corrosive nature of sulfur dioxide gases
- Definition of Fiberglass Reinforced Polymer (FRP) Composites
- Materials of construction for sulfur dioxide scrubbers
- Use of FRP is sulfur dioxide scrubbers & stacks
- Concluding remarks
History

- The Alpha Corporation and Owens Corning Resin and Coating division formed a joint venture in 1994, Alpha Owens Corning.

- The Alpha Corporation purchased the Owens Corning share of the joint venture in 1998, and AOC, LLC was formed.
History

- AOC is North America’s largest resin manufacturer, with 4 U.S. plants, and 1 each in Canada and Mexico.

- Globally, AOC is among the five largest in the world. European customers are serviced by plants located in the U.K., Poland and Slovakia. Asian-Pacific customers are serviced by plants in Thailand, India and Vietnam.
Coal Powered Power Plants

- Coal produces steam that powers steam generators
- Coals contain 2 – 6 % total sulfur
- Sulfur converts to SO$_2$ during combustion
- SO$_2$ forms sulfurous acid and sulfuric acid in the atmosphere
- Sulfur acids are deleterious to people and the overall environment if not removed from power plant exhausts
Overall Chemistry of Coal Combustion

Coal combustion

Coal plus oxygen yields heat, carbon dioxide and sulfur oxides

\[
\text{Coal} + \text{air} \implies \text{Heat} + \text{CO}_2 + \text{SO}_2 + \text{SO}_3 \\
+ \text{NO}_x + \text{H}_2\text{O}
\]
Chemistry of SO$_2$ Removal

Sulfur oxide gases are mixed with limestone
Limestone forms calcium salts with gases

SO$_2$ + SO$_3$ + CaCO$_3$ $\rightarrow$ CaSO$_3$ + CaSO$_4$ + CO$_2$
Corrosive Chemicals in Scrubber Solutions

- Chloride ions (up to 20,000 ppm)
- Sulfur dioxide and sulfur trioxide
- Calcium carbonate
- Nitrogen oxides

- All are corrosive to some materials of construction – the chloride ion is the most corrosive to metals, especially stainless steels
Definition of Fiberglass Reinforced Polymer (FRP) Composites

- A matrix of polymer materials that is reinforced by fibers or other reinforcing material.
  - For power plant application the polymer is usually a vinyl ester resin
  - The reinforcing fibers are typically glass fibers (fiberglass)
Examples of FRP in corrosive environments

Made from AOC Vipel® K022 Vinyl Ester
Examples of FRP in corrosive environments

Made from AOC Vipel® K022 Vinyl Ester
Examples of FRP in corrosive environments

Vipel® K022 Vinyl Ester

Courtesy of Air-Chem
Vipel® F737 – Seawater pipe – LNG re-gasification

Photo courtesy of PITSA
Vipel® F737 – Hydro Power Plant Penstocks - 1979

5620’ 10’ dia pipe
7808’ 12’ dia.pipe
Recently inspected – excellent condition
Vipel® F737 – Power Plant Cooling Water - 1978

3000' 16.3’ dia pipe – offshore with 2 – 150 10’ dia dispersion legs
Double O-ring Bell & Spigot joints
Inspected @ 22 years – like new!
FRP Composite Scrubbers and Stack Liners
Application for FRP in Power Plant
Scrubbers and Stacks

- FRP Piping
- Scrubber Internals
- Scrubber Vessels
- Stack Liners
- Ducting from scrubber to stack
Jet Bubble SO$_2$ Scrubber
The CT-121 Wet FGD Process

Source: B & V Chiyoda
Jet Bubble SO$_2$ Scrubber
The CT-121 Wet FGD Process

JBR Overview

Source: B & V Chiyoda
Applications

- Caustic piping and storage
- Waste water treatment
- Bleach piping and storage
- Neutralization tanks – Acid tanks
- Sulfonated detergent storage
Examples of FRP in Sulfur Dioxide Scrubbers

Vipel® F010 Vinyl Ester

Courtesy of RL Industries
Examples of FRP in Sulfur Dioxide Scrubbers
Vipel® F010 Vinyl Ester

Courtesy of RL Industries
Stacks & Stack Liners

Source: Pullman Power
FRP Composites in Stack Liner for Scrubbing SO$_2$
FRP Composites in Stack Liner for Scrubbing SO$_2$
FRP Composites in Stack Liner for Scrubbing SO$_2$
FRP Composites in Stack Liner for Scrubbing $\text{SO}_2$

Photo courtesy of Fiberglass Structural Engineering
Vipel® K022 Fire Retardant Vinyl Ester Resins Series

Features

- Corrosion and toughness typical of non-fire retardant vinyl ester series
- ASTM E-84 Class 1 fire
- Superior fire retardancy (by bromination, not additives)
FRP Composites in Stack Liner for Scrubbing SO$_2$

AOC Vipel® K022-AC

Photo courtesy Tri-Clor
Vipel® K022-AC – Stack Liner

Photo courtesy of Tri-Clor
High Temperature Vinyl Ester Resins for Chimney Liners
High Temperature Vinyl Ester Liners for Chimney Liners

**Length:**
- 236.2 feet (72 meters)

**Diameter:**
- 55 inches (1400 millimeters)

**Operating temperature:**
- 150°C (302°F)

**One-hour exposures:**
- 180°C (356°F)

**Resin:**
- Vipel® F086 - HT vinyl ester

Photo courtesy of Tunetanken A/S
## Comparative Liner Costs

<table>
<thead>
<tr>
<th>Material of Construction for Liner</th>
<th>Installed Cost, $/ft²</th>
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</thead>
<tbody>
<tr>
<td>Alloy C-276 over steel</td>
<td>225</td>
</tr>
<tr>
<td>Vinyl Ester FRP (Multiple liners possible)</td>
<td>125</td>
</tr>
<tr>
<td>Borosilicate Glass Block</td>
<td>125</td>
</tr>
</tbody>
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Source: Major Concrete Chimney Erector
Conclusions

- Coal fired power plants are one of the largest generators of SO$_2$ in the world
- Environmental regulations are requiring plants to be fitted with SO$_2$ removal equipment
- There are a variety of technologies for removing SO$_2$; wet SO$_2$ scrubbers are corrosive to many materials of construction.
- AOC has developed a Class 1 flame spread vinyl ester that does not require filler: Vipel® K022-AC
- Pipes, scrubbers & chimney liners made from FRP have a proven history in the power industry
How To Get Started

AOC can provide:

- Basic resin specifications & assistance with resin selection
- Fabricator referral lists
- Coupon testing & case histories

bbogner@aoc-resins.com or (630) 665-2675