Optimizing Catalyst Performance Aids in Lowering Operational & Management Costs

Santee Cooper, Cross Station Case Study

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TIFI® Targeted In-Furnace Injection™

- Highly reactive magnesium hydroxide \( \text{Mg(OH)}_2 \)
- Patented process using Computational Fluid Dynamic Modeling
- Critical Design Criteria
  - Furnace gas flows and temperatures
  - Chemical distribution, particle size and feed rate
CFD Modeling of Injection Strategy includes both Furnace and Backend
Controlling Slag, Fouling, $\text{SO}_3$
& Ammonium Bisulfate (ABS)

Critical to Optimizing Catalyst Life,
Costs, and Overall Unit Performance
TIFI reduces ABS, SO$_3$ and H$_2$SO$_4$

• Lower Furnace Temperature
  ▶ Decreased Oxidation Rate

• More Balanced Furnace
  ▶ Reduced Excess Oxygen

• Reduced Slag and Iron Deposits
  ▶ Less Catalytic Oxidation

• Direct Reaction with MgO
  ▶ MgO + SO$_3$ => MgSO$_4$
  ▶ MgO + NH$_4$HSO$_4$ => MgSO$_4$ + NH$_3$ + H$_2$O
Typical Fuels Used During This Study

• Sulfur
  - U1 \( \approx 3.3 \text{#/MMBTU} \)
  - U3,U4 \( \approx 4.5 \text{#/MMBTU} \)

• Iron
  - U1 \( \approx 23\% \text{ Iron} \)
  - U3,U4 \( \approx 25\% \text{ Iron} \)

Unit 1 - 600 MW Wall Fired
U3 & U4 - 600 MW T-Fired
TIFI Successfully Controlled

Primarily:

- $\text{SO}_3$ mitigation for Opacity Control
- ABS Formation
- Slag and Furnace Fouling
- Large Particle Ash (LPA)/Popcorn Ash
- SCR Fouling & AH Fouling

**Program Consistently Provided**

- Fuel Flexibility
- Unit Efficiency
- Unit Capability
Hard Slag Formation Has Been Controlled

Before TIFI slag

After TIFI treatment slag
SO$_3$ at 580 MW

Bar chart showing SO$_3$ ppm levels at different outlets:
- Economizer Outlet: Baseline 22 ppm, Treated 12 ppm
- SCR Outlet: Baseline 26 ppm, Treated 11 ppm
- Air Heater Outlet: Baseline 5 ppm, Treated 3 ppm

Note: Treated condition is with 5.0 lbs/Ton addition.
Inlet SCR Temperatures & Affect on SO$_3$

At 741° F there is 1% conversion of SO$_2$ to SO$_3$
At 760° F and 4% Excess O$_2$ – Additional 25% more SO$_3$
At 775° F and 4% excess O$_2$ – Additional 50% more SO$_3$

Fig. 7 SO$_2$ to SO$_3$ Conversion Rate VS. Gas Temperature in Base case
Managing Catalyst Life Cycle

- As Catalyst becomes depleted, ammonia slip increases.

- Ammonia slip in the presence of SO₃ will form ABS & influence Air Heater fouling

\[
\text{NH}_3 + \text{SO}_3 + \text{H}_2\text{O} \rightarrow \text{NH}_4\text{HSO}_4
\]
Managing Catalyst Life Cycle

• The greater the ammonia slip & fuel sulfur concentration, the faster AH dP will Rise

• Typically becomes more significant with fuel sulfur content above 1.5%
Unit 3 SCR Outlet Ammonia Slip

High Load

**Ammonia Slip**
B Duct, SCR Outlet

**Ammonia Slip**
A Duct, SCR Outlet

- NH₃ Slip (ppm as measured)
- Port Location
- West
- East
Initial ABS Control Demonstration

Santee Cooper Cross Station Unit 3
Gross MWs vs AH DP

- No ABS Control
- TIFI Adjusted for ABS control

Graph showing gross MWs and AH DP over time with two categories: MWS and AH A/B DP.
Cross 3 Air Heater Wash

![Graph showing Mg, NH3, Ca, and K levels during initial flush and wash phases.](image-url)
TIFI Clean-up of Air Heater
High Ammonia Slip- End of Catalyst Life

Load vs Dewpoint

ABS
Sulfuric Acid
Cat Layer Added

Load/ Dewpoint Temp

0 100 200 300 400 500 600 700

8/15/09 9/14/09 9/24/09 10/14/09 11/3/09 11/23/09 12/13/09 12/30/09
AH dP Went Down from 17.8” to 14.7”

TIFI Program Adjusted To Allow Unit To Make It To Outage
On Line Air Heater Clean-Up

High Ammonia Slip due to Ammonia control issues caused excessive ABS formation and Air Heater Fouling

No Shutdown Needed - Maintained Full Load
Air Heater dP reduced 6 inches
On Line Air Heater Clean-Up
No Shutdown - Maintained Full Load
• Unit 1 always had Large Particle Ash issues. When the SCR was installed, SCR fouling caused online SCR cleanings.
• Since TIFI began in April 2006, there has not been any increase in SCR DP from fouling.
• TIFI has allowed over 5 years of operation without the need for online SCR cleanings or caused significant increases in SCR differential pressure.
SCR Pressure Drop - Popcorn Ash

NET MW vs. SCR DP

Baseline

TIFI Treatment

DATE

4/18/05 5/26/05 7/19/05 8/27/05 10/1/05 11/17/05 12/14/05 2/5/06 4/18/06 6/3/06 7/11/06 8/23/06 9/29/06 11/17/06 12/22/06 2/4/07 3/28/07

Net MW

DP (in. H2O)

-5 0 5 10 15 20 25

-5 0 5 10 15 20 25

400 500 600 700

-Net MW

SCR "A" DP

SCR "B" DP

(Colors and data points indicating trends over time.)
Unit 1 - Exhausted Catalyst

• Catalyst OEM recommended Layer Removal & Replacement in April 2011
• Extended Performance with TIFI allowed one additional year of performance - 8000 Hours
• ABS Formation Controlled During Catalyst Degradation
SCR dP and Air Heater dP controlled over 19 months
Ammonia Slip from 3-15 ppm Since June 2011
Test Location

Full Load Ammonia Slip (ppm)

- SCR Outlet
- Flow
- Air Heater Inlet
- Plan View Front
- Rear

Graph showing ammonia slip for different test runs and ports:
- Port 1
- Port 2
- Port 3
- Port 4
Summary

• TIFI® Targeted In-Furnace Injection™ Successfully controlled slag, fouling, SO$_3$, & ABS

• Prevented ABS Formation, and removed ABS from a Fouled Air Heater

• Catalyst Life Significantly Extended by maintaining low SCR & AH dP

• Ammonia slip is managed - preventing need to buy new catalyst prematurely