Boiler Retirement – Something New to Consider

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EnerChem Incorporated

Louisville, KY August 15, 2012
BOILER RETIREMENT: CLEARCHEM IS SOMETHING NEW TO CONSIDER

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What is ClearChem (TM)?

• Furnace sorbent injection process

• Patented, based on micronized reagents, CaCO$_3$, CA(OH)$_2$, fly ash and industrial byproducts as powders or high solids dispersions

• Small footprint – simple Hardware

• Very low cost
What are ClearChem effects?

- Effective scavenging of $\text{SO}_2$, $\text{SO}_3$, and HCL
- High surface for capture of oxidized Hg
- Minimal tube deposits and impact on ESP
- Marketable dry ash – no pond leaching
- Allows lower exit gas temps and benefits
ClearChem Is New FSI Technology

- Decades old attempts at furnace sorbent injection (FSI) showed mixed results at best
- ClearChem is different – it solves past issues to release the promise of FSI:
  - Sub micron reagent particles avoid deposits
  - Computer Modeling assures proper distribution
  - Burner zone injection for longer reaction time
  - Better reagent utilization avoids ESP issues
# ClearChem Versus Old FSI

<table>
<thead>
<tr>
<th>ClearChem</th>
<th>Old FSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>70-84% SO₂ captured</td>
<td>30-50% SO₂ captured</td>
</tr>
<tr>
<td>Less than 2 Ca/S</td>
<td>More than 2 Ca/S</td>
</tr>
<tr>
<td>Normal soot blowing</td>
<td>Continuous soot blowing</td>
</tr>
<tr>
<td>Modest increase in ESP ash burden</td>
<td>Massive increase in ESP ash burden</td>
</tr>
</tbody>
</table>
Results of Pilot and 3 Short Boiler Trials

- 84% SO$_2$ capture at Ca/S =1.9
  - Lower exit temp will boost capture

- HCl capture circa 75%

- SO$_3$ virtually all captured
  - Allows lower exit gas temp, heat rate, CO$_2$ release
65 MW Coal Fired Utility boiler
3 micron vs. – 325 mesh powders

SO2 Capture as a Function of Ca/S

% SO2 Captured

Ca/S Ratio

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Results of Advanced Injector Tests

Advanced Injectors on 1MW Unit Using 3% Sulfer Coal

SO₂ Capture (%) vs. Stoichiometric Ratio

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Why is ClearChem More effective?

- Surface Area of 0.5 micron reagent is mostly external and 88 times that of 325 mesh
- Number of particles per lb of 0.5 micron reagent is 676,000 times that of 325 mesh
- Result: The probability of a reagent particle finding the scarce pollutant molecules in the huge volumes of flue gas is much greater
Costs and Benefits

• Capital cost: starting under $500,000/unit
• Operating cost: $400 – 600/ton SO$_2$ mitigated
• Safe, widely available, easily handled reagents
Additional Benefits

• Can make existing FGD more effective
• \( \text{SO}_3 \) removal eases oxidized Hg capture
• Existing \( \text{CaCO}_3 \) supply can be used
• Improves economics of flue gas \( \text{H}_2\text{O} \) recovery – nearly ton/ton coal – more on scrubbed units
Costs Can Be Reduced Further

• By capitalizing on SO$_3$ capture to lower flue gas temp – (investment required)
  – Improve unit heat rate – reduce CO$_2$ emission
  – Recover water from flue gas

• By enhancing reagent capture efficiency via
  – Lowering flue gas temperature - proven
  – Improving injector performance - projected
  – Utilizing byproduct or waste reagent – projected
EFFECT OF FLUE GAS COOLING ON SO2 CAPTURE

DOE Boiler Trials Using 325 Mesh Limestone Powder
Best Fit Solution

• ClearChem is the optimal solution for plants seeking to control costs associated with emissions control
  – Lower exit temps to enhance pollutant capture
  – Use less costly construction materials
  – Facilitate smaller less costly hardware
  – Makes DSI more cost effective
  – Maintains ash marketability – avoid pond leach
Comparative Cost Over Time
## ClearChem vs. DSI

<table>
<thead>
<tr>
<th></th>
<th>ClearChem</th>
<th>DSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>SO₂ Capture</td>
<td>70-84%</td>
<td>30-80%</td>
</tr>
<tr>
<td>Stoichiometric Ratio</td>
<td>Under 2</td>
<td>Over 2</td>
</tr>
<tr>
<td>Lbs/lbs SO₂</td>
<td>3.13</td>
<td>4.82</td>
</tr>
<tr>
<td>Application</td>
<td>dispersions</td>
<td>powder</td>
</tr>
<tr>
<td>Application Point</td>
<td>burner/nose</td>
<td>econ/ESP</td>
</tr>
<tr>
<td>Install Time</td>
<td>3-6 months</td>
<td>6-9 months</td>
</tr>
<tr>
<td>Costs, Capital</td>
<td>$400,000</td>
<td>$4,000,000</td>
</tr>
<tr>
<td>Reagent</td>
<td>$435-$802/ton SO₂</td>
<td>$1020-$1632/ton SO₂</td>
</tr>
</tbody>
</table>
### ClearChem vs. DSI

<table>
<thead>
<tr>
<th>Feature</th>
<th>ClearChem</th>
<th>DSI</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ash marketable</td>
<td>Yes</td>
<td>Yes/No</td>
</tr>
<tr>
<td>ESP impact</td>
<td>No (3 demos)</td>
<td>Yes/No</td>
</tr>
<tr>
<td>Reagent supply</td>
<td>Mostly local</td>
<td>More remote</td>
</tr>
<tr>
<td>Reagent handling</td>
<td>Easy</td>
<td>More labor</td>
</tr>
<tr>
<td>Safety &amp; corrosion</td>
<td>No</td>
<td>Yes</td>
</tr>
<tr>
<td>Landfill leaching</td>
<td>No</td>
<td>Yes/No</td>
</tr>
<tr>
<td>Furnace deposits</td>
<td>Minor</td>
<td>None</td>
</tr>
</tbody>
</table>
Company Status

- US Patents received and pending
- Three short (1 to 2 weeks) boiler trials completed
- First licensing agreements complete for reagent and applicator partners
- Preparing for large scale demonstration under utility operating conditions (1st half 2013)
- International patents pending
- Extending licensing partnerships to additional geographies
- Preparing an equity raise of $3-5 million
CFD modeling indicates best injection sites (2 nozzles at each of the OFA and Side Door ports). Above shows the pump skids and day tank.
Conclusions

• ClearChem has the potential to lower emission control costs across the board
  – Costs low enough to compete with retirement
  – Less expensive way to upgrade FGD systems
  – Reduce DSI operating costs
  – Practical way to control SO$_3$ & reap benefits
    • Reduce fuel consumption and CO$_2$ emissions
    • Recover H$_2$O from flue gas
    • Eliminate “blue plume”