WRBA 2010
March 16, 2010

Optimizing Fireside Heat Transfer Biomass

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Biomass Drivers

"Why worry about efficiency"

- Renewable Portfolio Standards
  - CA – 33% by 2020
  - OR – 25% by 2025
  - MT – 15% by 2015
  - WA – 15% by 2020
  - ID – none at present time

- Value ($) of Green MegaWatt
- Replacement Power Costs (outage)
- Cap and Trade/Gov’t Programs
Agenda

- Fuel Tech Company Overview
- Historical Issues/Challenges
- Combustion Challenges
- Fuel Relationship
- Slag/Ash Mitigation Solutions
- Plant Results
- Discussion – Next Wave
Fuel Tech Overview

- FUEL CHEM® Technology –
  - Slag and Corrosion Reduction with Efficiency Improvements
- NO\textsubscript{x} Reduction Technologies
  - LNB / OFA
  - SNCR – “NOx-OUT® and HERT®”
  - Advanced SCR – the Right Combination of Technologies to Suit Individual Needs
- Services
  - Fluid Dynamics Modeling and Optimization Studies of APC Equipment
  - SCR Consulting and Catalyst Management Services
Challenges to Fireside Heat Transfer Efficiency

Mechanical -
- Boiler/Fan Operation
- Air Control
- Mechanical Boiler Components
- Black Liquor Recovery Boilers
Challenges to Fireside Heat Transfer Efficiency

- Fuel Variables -
  - Fuel Moisture
  - Variable Fuel Sources
  - Co-Firing
  - Ash Constituents
GRATE/STOKER FIRED COMBUSTION PROBLEMS

- Bed/Grate Clinker Formation
- Lower Water Wall Slagging
- Upper Furnace Fouling
  - Super Heat Bundle
  - Reheat/Generating Bank
  - Economizer
- Air Pre-Heater Pluggage
- Corrosion
  - Hot Side Corrosion (O2 Issues)
  - Econ/APH Corrosion (Cl-)
  - Duct Work Corrosion (SO4)
- PLUME/OPACITY PROBLEMS
Heat Transfer Loss

<table>
<thead>
<tr>
<th>Scale Accumulation</th>
<th>% Loss</th>
<th>Soot Accumulation</th>
<th>% Loss</th>
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</thead>
<tbody>
<tr>
<td>1/64&quot;</td>
<td>5%</td>
<td>1/32&quot;</td>
<td>10%</td>
</tr>
<tr>
<td>1/32&quot;</td>
<td>9%</td>
<td>1/16&quot;</td>
<td>25%</td>
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<tr>
<td>1/16&quot;</td>
<td>12%</td>
<td>1/8&quot;</td>
<td>45%</td>
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<tr>
<td>1/8&quot;</td>
<td>20%</td>
<td>3/16&quot;</td>
<td>70%</td>
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<tr>
<td>3/8&quot;</td>
<td>50%</td>
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</table>
PROBLEM ASH CONSTITUENTS

- Sodium (Na)
- Calcium (Ca) - bark
- Vanadium (V)
- Potassium (K) - organic
- Phosphorus (P) – organic
- Silica/Alumina - soil
- Chloride (Cl)
- Iron/Zinc/Heavy Metals
## Biomass Samples
### 23 MW Stoker Grate

<table>
<thead>
<tr>
<th></th>
<th>Design Wood</th>
<th>Sludge</th>
<th>PJ</th>
<th>Cotton Wood</th>
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<tbody>
<tr>
<td>BTU/#</td>
<td>5330</td>
<td>1388</td>
<td>8173</td>
<td>5698</td>
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<tr>
<td>Moisture (%)</td>
<td>23.5</td>
<td>67.4</td>
<td>8.58</td>
<td>33.9</td>
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<tr>
<td>Sulfur (%)</td>
<td>.02</td>
<td>.04</td>
<td>.03</td>
<td>.008</td>
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<tr>
<td>Ash (%)</td>
<td>16.4</td>
<td>14.6</td>
<td>2.33</td>
<td>1.26</td>
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<tr>
<td>Remarks</td>
<td>“Normal” Operation Blend</td>
<td>“Jet Fuel”</td>
<td></td>
<td></td>
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</tbody>
</table>
CHEMISTRY RELATED PROBLEMS

- LOW MELTING COMPOUNDS
- CATA LYSIS OF SO$_2$ TO SO$_3$
- CHLORIDE VAPOR FORMATION
- POOR COMBUSTION
- GRATE PLUGGAGE
- PLUME PROBLEMS
- CARBON PROBLEMS
- SLAGGING & FOULING
Slag/Fouling Control

• MECHANICAL
  – BED CONTROL / AIR TUNING
  – SHOT GUN DESLAgGING
  – EXPLOSIVE DESLAgGING
  – PICKS & SHOVELS
  – CHILL & BLOW
  – WATER BLASTING
    • OFFLINE
    • ONLINE

• OPERATIONAL
  – FUEL SWITCHING
SLAG CONTROL AGENTS

MAGNESIUM HYDROXIDE

• PROS:
  – RAISES ASH FUSION TEMPS
  – SHEAR PLANES
  – BEST CRYSTAL MODIFIER = SOFT DEPOSITS
  – STRONGEST ACID NEUTRALIZER
  – HIGHEST REACTIVITY

• CONS:
  – FEEDING CONCERNS
FUEL TREATMENT HISTORY

- A 50+ Year Old “Solution”
- Chemistry works in Lab Every Time…

Challenge was to make it work the same way in an industrial utility Boiler.
FUEL TREATMENT – PAST HISTORY

World War II - Carpet Bombing

Fuel Belt Treatment
Fuel Belt Application

- CHEMICAL ADDED TO FUEL
- 80% STAYS IN BED
- 20% GOES TO TREAT FURNACE WALLS
- ECONOMICS & PERFORMANCE POOR
FUEL TREATMENT - PRESENT

Now - “Smart Bombs”

Laser-guided bombs
Using small lasers and the Global Positioning System, ground forces can find targets in a way that pilots cannot. The lasers are invisible to humans, yet they determine targets for the bombs.
2. The pilot receives the information and drops the bomb, which "sees" the laser and strikes the target.

Sources: Special Forces: A Guided Tour of U.S. Army Special Forces; Associated Press

Now - Targeted In Furnace Injection or “TIFI”
- Chemical added to flue gas
- >90% goes to treat problem areas
- Excellent economics & performance
- Patented technology
Technological Core Competency
Pendant Chemical Coverage
Front Wall Injector Paths
Left Wall Injector Paths
Right Wall Injector Paths
ALL MAGS ARE NOT ALIKE

3 SOURCES OF MAGNESIUM
- MINE
- SEAWATER
- BRINE (SUPERIOR CHOICE)

WHY???
- SHARP CRYSTALS & SPACING
- WATER ENTRAPMENT
- FLAPJACK-BUTTER ANALOGY
- EXPLOSION OF H₂O
- CONVERSION TO MgO

IDEAL GEOMETRY = MAXIMUM REACTIVITY
THEORY OF FUNCTION MAG PARTICLES

1. Water Droplet Travel Ends
2. Mg(OH)$_2$ heats up to 325°C
3. Mg(OH)$_2$ particle explodes
4. Hundreds of smaller MgO particles form

To Change The Deposit Morphology, The MgO Must Get INTO The Deposit:

Mg(OH)$_2$ particle explodes

Hundreds of smaller MgO particles form
Treated vs. Untreated Slag

1000x SEM Baseline Untreated Slag

1000x SEM TIFI Treated Slag
Chemical Delivered to a storage tank

At the manifolds the chemical is diluted with water

Chemical is pumped to individual feed manifolds

Chemical is atomized with air to meet the spray pattern called for in the CFD model.
SO HOW HAS THIS PERFORMED – STOKER GRATE FIRED BOILER??

• **GOAL #1** - Slagging on the back wall was significantly reduced:

However – there was still some slag build up on the walls, which would drip down onto the moving grate, causing the fuel bed to “plow”.

Before TIFI Treatment  
After TIFI Treatment
CFD MODEL USED TO MODIFY THE FEED SYSTEM TO “Re-TARGET” CRITICAL AREA ON SIDE WALL

- Original Feed Array
- Revised Feed Array Utilizing Angled Injector Tips

Area that still showed slag buildup

Lighter colors indicate higher chemical coverage
Super Heat Tubes – TIFI

Soot Blower Line
Super Heat Tubes – BELT
Generating Bank – TIFI
~30% Plugged
Golf Ball Size Clinkers
Fly Ash on Top
50% Plugged Fly Ash on Small Clinkers
Excess O2 Comparison

Higher O2:
Less Slagging
Operating Costs
What’s the Next Wave

- Co-Firing w/coal
- Coal Plants looking for wood
- Coal ➔ Biomass
- Torrefication
- Renegotiation of PPA Contracts
- ??????
<table>
<thead>
<tr>
<th></th>
<th>100% Coal</th>
<th>80% Coal, 20% Wood</th>
<th>80% Coal, 20% Grass</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Temp.</strong></td>
<td>1840 F Nose Temp.</td>
<td>1897 F Nose Temp.</td>
<td>1934 F Nose Temp.</td>
</tr>
<tr>
<td><strong>CO</strong></td>
<td>64 PPM CO</td>
<td>91 PPM CO</td>
<td>88 PPM CO</td>
</tr>
<tr>
<td><strong>NO</strong></td>
<td>326 PPM NO</td>
<td>329 PPM NO</td>
<td>319 PPM NO</td>
</tr>
</tbody>
</table>
• Thank You

• Questions?