“Minimizing Unplanned Outages and Boiler Fouling Utilizing On-Line Impulse Cleaning”
OPTIMIZING PLANT OPERATIONS

IMPULSE Cleaners can improve heat transfer efficiency, reduce operational and maintenance costs, and minimize or eliminate costly unplanned outages.

- Small-scale, single tube, hydrogen/air
- Ethylene/air, detonation fundamentals, high pressure
- Multitube, turbine interaction, mechanical analysis
ADVANTAGES OF IMPULSE CLEANERS

• The frequent, proactive operation of the impulse cleaner minimizes ash build up and sintering of deposits on heat transfer surfaces.

• Provides 360°, non line-of-sight cleaning that has the ability to remove tube-to-tube bridging and minimize platenization.

• No harsh leading edge tube cleaning, excessive tube corrosion or erosion problems as with steam soot blowers.

• Proven to provide up to a 0.5% (and greater) improvement in heat rate and decrease exit gas temperatures by 15°F to 30°F.

• Elimination of opacity spikes due to more regular, more efficient cleaning.

• No costly repair, maintenance or operational costs.

• Does not scavenge steam/Reduces steam use (cost of steam).

• Minimal intrusion into and out of boiler, has minimal installation footprint and minimal installation costs.
TYPICAL CHALLENGES WITH SOOTBLOWING

- Soot blowers are not able to clean the shaded areas behind the first rows of tubes.
- The accumulations in these blinded areas and are difficult to clean once they have had an opportunity to form a structure.
TYPICAL CHALLENGES WITH SOOTBLOWING

- Soot blower erosion is often the main contributing factor for loss of boiler availability.
- High velocity steam and improper alignment of the blower with respect to the furnace walls, superheater tubes, reheater tubes, economizer tubes or elements will accelerate the erosion of the tubes.
IMPULSE CLEANING
BOILER AREAS CONDUCIVE TO CLEANING

Molten deposits - *Not receptive to cleaning by IMPULSE cleaner*

*NOTE: Unless deposits are chemically altered to enhance removal

Elevated temps, possible plastic” ash - *Use caution*

Temps lower than 1,500°F – Very receptive to IMPULSE cleaners
Encompassing Shockwave Areas of platenization between boiler tubes

Boiler Tubes

Encompassing Shockwave

Areas of platenization between boiler tubes

- Intense cleaning waves approach tube surfaces, encompass tube surfaces, transition around to back side, reconnect, and continue travelling
- Non-Line-Of-Sight Cleaning
- Deep Penetration throughout tube bundle
- Non Erosive
CLEANING ACTION

- Supersonic shock waves penetrate the deposited material and reflects from tube walls and interior surfaces.
- Reflected waves propagate through the deposited material on the tube surface and reflect from this surface as rarefaction waves.
- Rarefaction waves propagate back toward the tube surface.
- The sequence of reflection waves and their subsequent attenuation lead to loosening and removal of deposit.
Acoustic cleaners utilize sound waves to create particle displacement in order to resonate and dislodge particulate deposits.

Particle displacement

- A shock wave is characterized by a sharp increase in pressure and temperature across a boundary.
- They are orders of magnitude more intense than sound waves.
- The resulting shockwaves provide a large amount of cleaning energy.
- The instantaneous rise in pressure excites the deposits.
- A typical cleaning cycle would consist of 2 detonations per second, for 10 seconds (20 detonations).

Shockwaves create an extremely rapid rise in pressure and density. They can produce localized pressures above 14 PSI.

Acoustic Cleaning

Pulse Detonation

Generally less than one-tenth of one PSI pressure change.
IMPULSE Cleaners are constructed from 3 separate pieces.

- **A**: Combustion chamber, is fabricated from stainless steel and is about 48” long and 2” in diameter.

- **B**: Casting that diverges from two-inches out to approximately 6” in diameter over an axial length of 30”. There are two options: a straight or curved version. The curved section has a 90-degree bend, a slim mounting profile.

- **C**: Typically located inside the boiler, this can be recessed to be mounted flush in the boiler. It diverges from 6” out to 16” over an axial length of 30”.
SYSTEM COMPONENTS

- Combustion Assembly
- Control System
- Fuel Manifold
HOW IT WORKS
IMPULSE Cleaning Technology Case Study

Western Sugar

Project Overview

- Boilers were experiencing severe pluggage across the superheat area and unable to keep boilers in service during peak processing season
- Slag mitigation technology was ineffective forcing outages to clean boiler tubes
- IMPULSE cleaners installed on both units Fall 2011

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>PRB Coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Size</td>
<td>Two 125,000 lb/hr units</td>
</tr>
<tr>
<td>Boiler Type</td>
<td>Stoker</td>
</tr>
</tbody>
</table>

Results

- Successful installation
- Improved reliability and performance
- Maximized production allowing for operation during the entire 9-month operating season with no need for a forced outage

Generating section prior to injection of fuel additive and IMPULSE cleaners
IMPULSE Cleaning Technology Case Study
Dynegy – Vermilion Power Station, Unit 1

Project Overview
• Remove ash from unit’s spiral wound tube economizer
• IMPULSE cleaners installed on east and west sides of boiler in March 2009

Results
✓ Increased ΔT across economizer over 70° F
✓ Decreased air heater outlet temperature by over 15° F
✓ Over 0.5% improvement in heat rate

<table>
<thead>
<tr>
<th>Feature</th>
<th>Specification</th>
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</thead>
<tbody>
<tr>
<td>Fuel Type</td>
<td>PRB Coal</td>
</tr>
<tr>
<td>Unit Size</td>
<td>164 MW</td>
</tr>
<tr>
<td>Boiler Type</td>
<td>Peaking</td>
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</tbody>
</table>

![Graph showing economizer outlet temperature](image)
IMPULSE Cleaning Technology Case Study
FirstEnergy, Unit 5

Project Overview
- Fuel switching lead to platenization and pluggage problems in backpass which sootblowers could not resolve
- Economizer – stagger Fintube arrangement
- Six (6) IMPULSE cleaners installed in March 2007
- Each unit performs one cleaning cycle for every two hours which are 10 seconds long (20 impulses)

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>Eastern Bituminous Coal switched to PRB Coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Size</td>
<td>264 MW</td>
</tr>
<tr>
<td>Boiler Type</td>
<td>CE Twin Furnace</td>
</tr>
</tbody>
</table>

Results
- Over 20° F increase in steam outlet temperature across Low Temperature Superheater
- 33° F decrease in Economizer Gas Outlet Temperature
- >25° F decrease in Air Preheater outlet temperature
- 30% improvement in APH ΔP
- Noted improvement in ESP collection efficiency
- No unplanned outages due to fouling
- Internal inspections have confirmed boiler cleanliness

Before IMPULSE Cleaners

After IMPULSE Cleaners
IMPULSE Cleaning Technology Case Study
Xcel, Sherco Station – Unit 3

Project Overview
- Eliminate tube erosion to increase tube life
- Improve heat rate
- Minimize or eliminate use of sootblowers
- One (1) IMPULSE cleaner was installed on west side of boiler through existing backpass access door
- Flue gas temperatures were approximately 1200° F

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>PRB Coal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unit Size</td>
<td>910 MW</td>
</tr>
<tr>
<td>Boiler Type</td>
<td>Front Wall-Fired</td>
</tr>
</tbody>
</table>

Results
- IMPULSE cleaning system was successful, reducing gas temperature from 1200° F to 1,152° F
- Unit in operation with isolated steam sootblowers for 14 days, all camera and visual inspections showed the tube services remained clean
- Visual inspections showed the test area was as cleaner, or cleaner, than the corresponding area on the east side where sootblowers were used
- IMPULSE cleaners were able to retroactively clean heat transfer services after a test was run allowing for the creation of hardened ash deposits – within two hours the cleaners returned the boiler to pre-fouling level
IMPULSE Cleaning Technology Case Study
Kalaeola Partners – Kapolei, HI

Project Overview

- Bi-weekly outages to perform boiler/turbine wash and fouling turned to “cement” after washes if not completed
- DP across tube banks and stack temperatures increased throughout cycle due to fouling
- Very aggressive fin tube arrangement, small spacing between tubes and fins
- 4 IMPULSE cleaners were installed

<table>
<thead>
<tr>
<th>Fuel Type</th>
<th>#6 Oil</th>
</tr>
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<tbody>
<tr>
<td>Unit Size</td>
<td>2 units - 208 MW each</td>
</tr>
<tr>
<td>Boiler Type</td>
<td>HRSG</td>
</tr>
</tbody>
</table>

Results

- Customer wanted to reduce water washes and maintain heat transfer
- Customer experienced positive results immediately after trial startup
- Have maintained stack temperatures at acceptable levels
- Have gone 5 years with only 1 wash/year

Old tubes with serrated fins.
New solid fins with larger spacing between tubes
# Partial Installation List

<table>
<thead>
<tr>
<th>Company</th>
<th>Plant/Station Name</th>
<th>City</th>
<th>State</th>
<th>Boiler Size</th>
<th># of IMPULSE Cleaners</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Covanta Energy</td>
<td>Westbury</td>
<td>Westbury</td>
<td>NY</td>
<td>36</td>
<td>27 Units</td>
<td>Trash incineration, 3 Steinmueller Boilers producing 117,170 lb/hr of steam</td>
</tr>
<tr>
<td>First Energy</td>
<td>Sammis</td>
<td>Stratton</td>
<td>OH</td>
<td>300</td>
<td>3 Units</td>
<td>Not currently running-Plant Shut down</td>
</tr>
<tr>
<td>First Energy</td>
<td>Ashtabula</td>
<td>Ashtabula</td>
<td>OH</td>
<td>268</td>
<td>6 Units</td>
<td>Plant has been shut down</td>
</tr>
<tr>
<td>First Energy</td>
<td>Bruce Mansfield</td>
<td>Shippingport</td>
<td>PA</td>
<td>914</td>
<td>2 Units</td>
<td>Units being installed now</td>
</tr>
<tr>
<td>Dynegy</td>
<td>Wood River</td>
<td>Alton</td>
<td>IL</td>
<td>446</td>
<td>4 Units</td>
<td>Backpass and tubular air heater</td>
</tr>
<tr>
<td>Dynegy</td>
<td>Vermillion</td>
<td>Oakwood</td>
<td>IL</td>
<td>70</td>
<td>2 Units</td>
<td>Plant has been shut down</td>
</tr>
<tr>
<td>Dynegy</td>
<td>Hennepin</td>
<td>Hennepin</td>
<td>IL</td>
<td>293</td>
<td>6 Units</td>
<td>Being installed now</td>
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<tr>
<td>Xcel Sherburne</td>
<td>SHERCO</td>
<td>Becker</td>
<td>MN</td>
<td>900</td>
<td>18 Units</td>
<td>Unit 3 Boiler</td>
</tr>
<tr>
<td>Xcel</td>
<td>Redwing</td>
<td>Redwing</td>
<td>MN</td>
<td>9</td>
<td>1 Unit</td>
<td>Heat Exchanger of Trash Burner</td>
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<tr>
<td>CPCC (Cement)</td>
<td>Mojave</td>
<td>Mojave</td>
<td>CA</td>
<td>--</td>
<td>2 units</td>
<td>Downcomer duct-Shut down</td>
</tr>
<tr>
<td>PGE</td>
<td>Boardman</td>
<td>Morrow</td>
<td>OR</td>
<td>600</td>
<td>2 Units</td>
<td>HRSG</td>
</tr>
<tr>
<td>Kalaeloa Partners</td>
<td>Kapolei</td>
<td>HI</td>
<td></td>
<td>208</td>
<td>4 units</td>
<td>HRSG</td>
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</table>
## PARTIAL INSTALLATION LIST

<table>
<thead>
<tr>
<th>Organization</th>
<th>City</th>
<th>State</th>
<th>Zip Code</th>
<th>Units</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>KC Board of Public Utilities</td>
<td>Nearman</td>
<td>Kansas City</td>
<td>KS</td>
<td>261</td>
<td>2 units</td>
</tr>
<tr>
<td>City Utilities of Springfield</td>
<td>James River</td>
<td>Springfield</td>
<td>MO</td>
<td>96</td>
<td>2 units</td>
</tr>
<tr>
<td>City Utilities of Springfield</td>
<td>Southwest Stn</td>
<td>Springfield</td>
<td>MO</td>
<td>195</td>
<td>2 units</td>
</tr>
<tr>
<td>TVA</td>
<td>Gallatin</td>
<td>Gallatin</td>
<td>TN</td>
<td>320</td>
<td>8 Units</td>
</tr>
<tr>
<td>BP Cherry Point</td>
<td>Blaine</td>
<td>WA</td>
<td>--</td>
<td>1 Unit</td>
<td>Refinery Recuperator</td>
</tr>
<tr>
<td>Western Sugar</td>
<td>Scottsbluff</td>
<td>NE</td>
<td>--</td>
<td>2 Units</td>
<td>2 identical Stoker boilers producing 125,000 lbs/hr of steam each</td>
</tr>
<tr>
<td>Westar</td>
<td>Jeffrey Stn</td>
<td>St Mary’s</td>
<td>KS</td>
<td>720</td>
<td>6 Units</td>
</tr>
</tbody>
</table>