Control of Sox Nox – Coal Fired Power Plants

Innovation is anything, but business as usual
Presence of SO2 & NOx in flue Gas

• Emissions from a Power Plant Predominantly consist of CO2, & in small quantities - CO, Sulphur-Di-Oxide (SO2), Oxides of Nitrogen (Nox), Particulate matter etc.

• Quantity of SO2 in the Exit Flue gas depends on the Sulphur Content in the Coal and Quantum of Coal Fired in the Power Plant.

• Level of Nox in the flue gas depends on the combustion process & Nitrogen in Coal.
Present Scenario

- Indian Coal have Sulphur content of about 0.2 to 0.3% and hence Power Plants using only Indian Coal never gave any importance for So2 emissions.

- In fact no specific Environmental Standards were Prescribed for SO2 Emissions earlier, except those power plants located in Eco-sensitive Zones and in Cities.

- However with New Emission Standards which are recently introduced, will pose big challenge to the Power Plants to control the So2 & NOX Emissions.
# Comparison of Environmental Standards

<table>
<thead>
<tr>
<th>Period</th>
<th>Emission Parameters</th>
<th>Standards</th>
<th>Remarks</th>
</tr>
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<tbody>
<tr>
<td>Power Plants Commissioned before 31st Dec-2003</td>
<td>Particulate Matter</td>
<td>100 mg/ N cumt</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SO2</td>
<td>600 mg/ N cumt</td>
<td>Units Smaller than 500 MW</td>
</tr>
<tr>
<td></td>
<td>NOX</td>
<td>600 mg/ N cumt</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Hg</td>
<td>No Limit Given</td>
<td>Units Smaller than 500 MW</td>
</tr>
<tr>
<td></td>
<td></td>
<td>0.03 mg/ N cumt</td>
<td>Units Capacity 500 MW and above</td>
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<tbody>
<tr>
<td>Power Plants Commissioned before 31st Dec-2016</td>
<td>Particulate Matter</td>
<td>50 mg/ N cumt</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SO2</td>
<td>600 mg/ N cumt</td>
<td>Units Smaller than 500 MW</td>
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<tr>
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<td>NOX</td>
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<td></td>
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<td>For all Units</td>
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<tr>
<td>Power Plants going to be Commissioned after 1(^{st}) Jan-2017 (Plants Under Approval Stage / Under Construction)</td>
<td>Particulate Matter</td>
<td>30 mg/ N cumt</td>
<td></td>
</tr>
<tr>
<td></td>
<td>SO2</td>
<td>100 mg/ N cumt</td>
<td>For all Units</td>
</tr>
<tr>
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Innovative Solution for SOX Nox reduction - Use of Thermact (Fire Side Fuel Additive)
SOx Formation

• SO₂ & SO₃ are formed in normal combustion process.

- \[ S + O₂ \rightarrow SO₂ \]
- \[ 2 SO₂ + O₂ \rightarrow 2SO₃ \]

Vanadium present in the coal mix with Oxygen to form V2O5 which act as a Catalyst to form SO2 to SO3.
NOx Formation

• Nox is by product of Combustion
• Nitric Oxide(NO), Nitrogen-di-oxide(NO2), Nitrous oxide(N2O)
• Pollutant of - Ozone depletion, acid rain particulate matter
NOx Formation

In Coal Fired Boilers:

- Thermal NOx: 19%
- Fuel NOx: 80%
- Prompt NOx: 1%

Reaction of O2 & N2 under high temperature
Exponential function of Flame temperature
NOx FORMATION

- [Diagram showing NOx formation rate against flame temperature in Fahrenheit]

- [Graph with axes labeled NOx Formation Rate on the y-axis and Flame Temperature, F on the x-axis, with a trend line indicating the relationship between the two variables]
Thermact - A unique Technology for reduction of SO\textsubscript{x} NO\textsubscript{x}

- Fire side combustion catalyst.
- Pure Hydrocarbon.

- The catalyst weakens bonds between the hydrogen and carbon atoms, so that disassociation takes place faster.
Working Principle

Catalyst 1

\[ \text{C} + \text{H}_2\text{O} \rightarrow \text{CO} + \text{H}_2 \]

Catalyst 2

\[ \text{C} + \text{H}_2 \rightarrow \text{CH}_4 \]

Fixed Moisture

H₂O

Carbon Particle

\[ \text{CH}_4 \rightarrow \text{heat given} \]

\[ \text{Reduction in coal consumption / GUHR} \]
- Catalyst in THERMACT in presence of inherent moisture trapped in coal, converts the carbon atoms in coal into allotropic clusters by using the phenomenon of carbon co-valancy by sharing electrons.

- In the classical theory, these allotropic clusters which are in the shape of soccer ball, are known as Bucky-balls.
Bucky ball

Spatial Model

Three Dimensional Model showing electron Bonds
Although coal is primarily a mixture of carbon (black) and hydrogen (red) atoms, sulfur atoms (yellow) are also trapped in coal, primarily in two forms. In one form, the sulfur is a separate particle often linked with iron (green) with no connection to the carbon atoms, as in the center of the drawing. In the second form, sulfur is chemically bound to the carbon atoms, such as in the upper left.
Sulphur Trapping

THERMACT traps Sulphur which is in free form

THERMACT makes it possible to trap Sulphur atom, in the hollow structure of the bucky-balls, which acts like a molecular cage. Due to this Sulphur in Bottom Ash increases.
**SO$_2$ & SO$_3$ formation**

THERMACT reduces $S_{O_x}$ formation.

In the presence of THERMACT the bucky-balls formed reacts with $SO_2$ to form a polymeric compounds which comes down into bottom ash.

$SO_2 + SO_3^-$

Due to this phenomenon $SO_x$ emissions are reduced. Sulphur in fly ash is reduced & that in Bottom Ash is increased.
SOx Formation

• SO$_2$ & SO$_3$ are formed in normal combustion process.

• S + O$_2$ $\rightarrow$ SO$_2$

• 2 SO$_2$ + O$_2$ $\rightarrow$ 2SO$_3$

Vanadium present in the coal mix with Oxygen to form V2O5 which act as a Catalyst to form SO2 to SO3.

But due to presence of catalyst, less free oxygen is available after combustion - does restrict formation of V2O5, instead form V2O4 & V2O3. Resulting into reduced SOX Emissions.
# Case Studies

**Bundel T.P.S (210 MW)**

<table>
<thead>
<tr>
<th></th>
<th>Without Using Fuel Additive (Thermact)</th>
<th>During Usage of Fuel Additive (Thermact)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sulphur in Bottom Ash</td>
<td>0.08%</td>
<td>0.22%</td>
</tr>
<tr>
<td>SO2 Emissions in Exit Flue Gas</td>
<td>368 mg/Nm3</td>
<td>268 mg/Nm3</td>
</tr>
</tbody>
</table>

**Durgapur (210 MW) @ Operating Load 165 MW**

<table>
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<th>During Usage of Fuel Additive (Thermact)</th>
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<tbody>
<tr>
<td>Sulphur-Di- Oxide</td>
<td>286 mg/Nm3</td>
<td>258 mg/Nm3</td>
</tr>
</tbody>
</table>
## Case Studies

### Nalco Damanjodi (200 TPH - AFBC) - Fuel Coal

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<th>During Usage of Fuel Additive (Thermact)</th>
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<tbody>
<tr>
<td>NOX Emissions</td>
<td>245 ppm</td>
<td>152 ppm</td>
</tr>
</tbody>
</table>

### KSK, Vijayawada (90 MW - AFBC)

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<th>During Usage of Fuel Additive (Thermact)</th>
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<tbody>
<tr>
<td>NOX Emissions</td>
<td>1040 mg/Nm3</td>
<td>679 mg/Nm3</td>
</tr>
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</table>
## Case Studies

**Shree Rama News Print Limited (90 TPH AFBC Boiler) - Surat**

<table>
<thead>
<tr>
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<th>During Usage of Fuel Additive (Thermact)</th>
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<tbody>
<tr>
<td>SOx</td>
<td>434.8 ppm</td>
<td>285.1 ppm</td>
</tr>
<tr>
<td>NOx</td>
<td>142.5 ppm</td>
<td>89.6 ppm</td>
</tr>
</tbody>
</table>
Case Studies

U S STEEL, KOSICE

- Boiler No -4 is continuously running from 17th May without any shutdown in comparison to other Boilers.
- Reduction in SOx by 33.30%
- Reduction in NOx by 21.35%
NOx REDUCTION

Flame Profile

Flame Profile with Use of additive
NOx REDUCTION

Fuel NOx:

• Reaction of Nitrogen in Fuel with Oxygen in air

Prompt NOx:

• Reaction of Hydro Carbon fragments with atmospheric Nitrogen

Techniques:

• Combustion Control
• Post Combustion

By Optimised Combustion:

• Balance of Primary air & Fuel Flow to Burners
• Control of Secondary air
• Burner tilts
• Lower Excess Air
• Boiler Cleanliness
THERMAC (Fuel Additive) BENEFITS:

- Reduction in Total Air
- Faster Combustion
- Removal of Deposits
- Uniform Furnace temperature
Clinker Photos During Thermact Usage

Near Soot blower 175

Before THERMACT

With THERMACT
Clinker Photos During Thermact Usage

Near Soot blower 176

Before THERMACT

With THERMACT
IIT, Bombay: R & D Highlights

Technologies Transferred / Licensed

Direct licensing
- Board games design
- Ethernet switch routers
- WebNRC for product design and process planning for CNC machining
- Y-shaped concentrated modules
- Soil biotechnology for waste management
- Software for lid matching in day-ahead spot electricity market
- Multi utility heat pump technology
- Hybrid cooling system technology

Licensing through collaborative development
- Amplified fluorescence polymers as TNT sensors
- Asymmetric device applications in advanced CMOS technologies
- Design of ATM Enclosure - ASAN
- Fuel additives for improving efficiency
- Laminated object manufacturing - rapid prototyping process
- Short term load forecasting
- Silicon coating for cardiac monitoring
- Steer-by-wire system for vehicle
- Supercritical fluid extraction technology

http://www.iitb.ac.in/licensing

Multi-utility heat pump
Municipal hybrid air conditioner
Sewage treatment plant set up at BMC, Mumbai
Steer-by-wire system for vehicle
Fuel additives
Indian Institute of Technology, Bombay

TO WHOMSOEVER IT MAY CONCERN

THIS IS TO CERTIFY THAT "THERMACT", A FIRESIDE ADDITIVE IS DEVELOPED AND TESTED IN OUR LABORATORY.

IT CONTAINS THERMOACTIVE ORGANO MATERIALS IN POWDER FORM. THE INGREDIENTS USED ARE TOTALLY NON-HAZARDOUS, ENVIRONMENTALLY FRIENDLY & FULLY SAFE FOR INDUSTRIAL USE ESPECIALLY IN BOILERS & FURNACES.

"THERMACT" IS SPECIALLY RECOMMENDED FOR ALL SOLID FUELS LIKE COAL, BAGGASSE ETC.

"THERMACT" CAN BE USED FOR MORE COMPLETE COMBUSTION WHICH IN TURN REDUCES SMOKE EMISSION SUBSTANTIALLY.

YOURS SINCERELY,

[Signature]

Professor

Department Of Chemistry

Indian Institute of Technology, Bombay, Mumbai-78
Manufacturing Unit at Baddi, Himachal Pradesh
MAKE IN INDIA

Pan IIT Pavilion
THE GREEN ERA
INTERNATIONAL
AWARD - 2016
FRANCE

FOR
CONTRIBUTION TO THE PRESERVATION
AND IMPROVEMENT OF THE
ENVIRONMENT IN INDIA.
The President Of Association Otherways Management & Consulting France certifies that

Abhitech Energycon Limited

has been selected to receive
The Green Era Award for Sustainability

28th November 2016
Dubai-U.A.E

The President,
Charbel S. Tabet
GREENTECH ENVIRONMENT MANAGEMENT

AWARD - 2016
INDIA

FOR
EXCELLENCE IN ENVIRONMENT MANAGEMENT
Major Customers in INDIA

- Gujarat Costal (CGPL)
- Adani Power Ltd.
- Tata Power Ltd.
- Tenughat TPS
- MAHAGENCO
  - Chandrapur TPS
- MPEB
- NALCO
- UDUPI POWER
ABHITECH COMPANY PROFILE

- 340 EMPLOYEES
- 240 TECHNICAL STAFF
- 5 ZONAL OFFICES
- 12 STATE OFFICES
EXISTING COMPANIES

- ABHITECH s.r.o. – Czech Republic, Ostrava
- ABHITECH GHANA LTD
- ABHITECH ENERGYCON EGYPT LTD

PROPOSED COMPANIES

- BRAZIL
- SAUDI ARABIA
- BANGLADESH
122 MMT of coal is equivalent to 1 x 500 MW unit run for 81 years with THERMACT continuously.
<table>
<thead>
<tr>
<th><strong>Manufacturer</strong></th>
<th>ABHITECH ENERGYCON LTD</th>
</tr>
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<tbody>
<tr>
<td><strong>Name</strong></td>
<td>THERMACT</td>
</tr>
<tr>
<td><strong>Packing</strong></td>
<td>20 Kg Silsack Bag</td>
</tr>
<tr>
<td><strong>Appearance</strong></td>
<td>Black Colour (Powder Form)</td>
</tr>
<tr>
<td><strong>Odour</strong></td>
<td>Odourless</td>
</tr>
<tr>
<td><strong>Dosage</strong></td>
<td>1 Kg of THERMACT for 15 to 20 Tons of Coal</td>
</tr>
</tbody>
</table>
BENEFITS OF THERMACT

- Reduction in GUHR.
- Reduction in Unburnts in Ash.
- Reduction in emissions (So2 & NOx).
- Reduction in Auxiliary power consumption.
- Reduction in Slag & Clinker.
- Uniform heat gradient leading to less tube failures.

Mitigated 10 Million Tons of Greenhouse Gases during last 10 Years and also saved fuel worth 150 Million USD.
Thank you!