NOx CONTROL FOR HIGH ASH COAL-FIRED PLANT

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• India – new norms
• NOx control in general
• NOx control options for high ash coal
• Multi-pollutant systems
New Indian norms are broadly similar to those in the EU and USA

Controls will have to be installed on most of the units

Revisions expected after results of pilot tests are clear

<table>
<thead>
<tr>
<th>Plants built</th>
<th>Limits (mg/m³)</th>
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<tbody>
<tr>
<td></td>
<td>PM</td>
<td>SO₂</td>
</tr>
<tr>
<td>&lt;2003</td>
<td>100</td>
<td>600*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>200**</td>
</tr>
<tr>
<td>&gt;2003</td>
<td>50</td>
<td>200**</td>
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<tr>
<td>&gt;2017</td>
<td>30</td>
<td>100</td>
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<500 MW, ** >500MW
• Electricity demand is expected to increase from 776 TWh in 2012 to 2499 TWh by 2030

• Big push for renewable energy (40% of non fossil fuel capacity by 2030)

• Commitment to decrease CO₂ emission intensity (33-35% of GDP by 2030 from 2005 levels)

• Large coal reserves

(NTPC, 2017)
High ash coal

Technical

Financial

Time constraints

Materials and reagent availability

No experience in continuous emissions monitoring (CEM)

The first ever technical guidance manual for emissions monitoring in India has been issued recently (CEMS, 2017)
• There are a number of DeNOx technologies
• They are frequently combined together
• Their NOx reduction rates and costs vary considerably
• Low NOx burners (LNBs)
• Over-fire air (OFA)
• Fuel biasing
• Low excess air
• Fuel reburning
• Flue gas recirculation
• Combustion optimisation

GE’s Low NOx burner (GE Power, 2018)
Main options for India – LNBs and OFA

Both technologies are already in use in Indian plants

Recent developments in LNBs address specific requirements of Indian market

Following installation, careful measurement and control of combustion parameters is a must

Doosan Babcock and Doosan Heavy Industries’ high ash coal (HAC) burner designed for Indian market (Wankhede and others, 2016)
• Selective catalytic reduction (SCR)
• Selective non-catalytic reduction (SNCR)
• Combination of SCR and SNCR?
• Multi-pollutant controls???

Basic principle of DeNOx (Kassi, 2016)
SCR – CONFIGURATION CHOICES

- **Hot-side, high dust SCR**
  - Boiler
  - NH₃
  - Selective catalytic reduction
  - Air heater
  - Electrostatic precipitator
  - Flue gas desulphurisation
  - Stack

- **Hot-side, low dust SCR**
  - Boiler
  - Electrostatic precipitator
  - NH₃
  - Selective catalytic reduction
  - Air heater
  - Flue gas desulphurisation
  - Stack

- **Cold-side SCR, tail end**
  - Boiler
  - Air heater
  - Electrostatic precipitator
  - Flue gas desulphurisation
  - Duct burner
  - Selective catalytic reduction
  - Stack

(BHEL, 2016)
More than 85% of global systems are in this lay-out.

Common perception is that plate catalyst experiences less plugging than the honeycomb, but this is not the case.

Successfully used in cement kilns, where dust loading is up to 100 g/m$^3$.
**Issues:**

- ash clogging the catalyst cells
- ash eroding the catalyst
- fouling by poisons such as calcium and arsenic
- erosion of various parts (ductwork, LPA screens, AIG nozzles, flow distribution devices)

**Solutions:**

- proper selection of the catalyst
- particle and dust removal systems
- reinforcement of the catalyst edge
- optimisation of pore structure of the catalyst
- minimising the flue gas angle entering the SCR catalyst and velocity maldistribution at catalyst inlet
- use of wear-resistant materials
Forward thinking:

Placing an SCR after a dry flue gas desulphurisation (FGD) unit which uses a SOx adsorbent made of fly ash, calcium hydroxide and the used SOx adsorbent as adhesive; as such the FGD can remove more than 85% of the dust.

This, in combination with an ESP, would mean a low dust environment and would avoid problems related to a high ash coal.

(Nakamura, JGC C&C, Japan, 2016; CEA-JCOAL workshop)
SCR catalyst can be a key component for mercury oxidation

(Vollmer, 2016)
• NOx reduction of 30-50%
• Number of vendors
• Proven in boilers firing high ash lignite and in cement kilns
• In India, an SNCR unit will have to cover a greater area and not all types of spraying nozzle will be applicable – this can be verified with CFD modelling and field tests
• Urea may be a better choice than ammonia
• SCR levels of NOx control achieved when SNCR used in conjunction with LNBs, OFA ...
SNCR - EXAMPLES

• Applicable to large boilers
• Use of advanced sensors to map the furnace and to control the location and manner of injection
• System successfully used in China since 2007, on a lignite firing boiler with 27.5% ash content

Advanced-SNCR using multiple nozzle lances from Fuel Tech Inc (de Havilland, 2016)
Successful examples in Poland, where the system is installed on lignite-fired boilers with 28% ash content fuel.

MOBOTECE’S ROTAMIX injector (Higgins and others, 2010)
• Relatively recent development
• Urea is sprayed within the furnace with a nozzle that is adjustable in height
• Tested on lignite with 34% ash content

All variations depend on the boiler characteristics. (One lance for vertical and horizontal injections shown) (Wilde, 2017)
As India is introducing emission standards for other pollutants, and pollution control technologies are expensive and require significant time to install, which in turn means disrupting power generation, it would make sense to co-ordinate installation of pollution control systems and to focus on multi-pollutant control systems.
ReACT™

- A regenerative activated coke dry-type technology for SOx, NOx and Hg removal

- Placed downstream of the electrostatic precipitator (ESP) for particulate control, so is not affected by ash loading

- In commercial use for several years (Isogo power plant)

- One stage (50% NOx removal) or two stage configuration (80% NOx removal)

Photo: Isogo power plant, Japan. Source: Hamon Group
• NOx scrubbing
  • Injects ozone downstream of air heater
  • Converts insoluble NOx to highly soluble $\text{N}_2\text{O}_5$
  • Capture in a wet FGD
  • No $\text{SO}_2$ to $\text{SO}_3$ oxidation
  • 50-70% Hg oxidation

• Installed in the refining sector
• EPRI pilot demo on 550 MW coal-fired plant
• An option for Indian plants with a wet FGD?

(Liu, 2016)
• **LNBs and OFA** – the majority of plants have been scheduled to retrofit primary measures during 2017 and 2018

• Following primary measures installation, appropriate **monitoring and control** of combustion parameters (combustion optimisation) **is a must**

• **SCR and SNCR** – utilities are not expected to make decisions on secondary controls until tests results from NTPC units are known (2019?)

• Multi-pollutant controls?
Choosing appropriate NOx control systems requires a site-specific strategy.

NOx controls for high ash coals are broadly the same as for ‘regular’ boilers, but they must be customised to local market requirements, as has already happened with LNBs.

SNCR and SCR tests results from NTPC units will pave the way for the installation of these technologies in India.

Potential contracts with suppliers should have some flexibility and there should be provisions for future possible technical changes.

The challenge facing Indian utilities is huge.
THANK YOU FOR LISTENING

Any questions?

Next webinar 21 March
Coal-derived wastes as a source of energy
by Dr Stephen Mills

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