Advanced Layered Technology Approach (ALTA) for NOx Reduction

For Energy and Environmental Solutions

REACTION ENGINEERING INTERNATIONAL

Hot Topic Hour

Coal-fired Power Plant NOx Reduction Innovations

November 6, 2014

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NOx Emissions
Don’t SCRs Solve This Problem?

• Cost
  – Power producer goal is not “lowest NOx”; goal is emissions compliance at lowest cost
  – High capital cost for small units

• Catalyst blinding for some coals

Advanced in-furnace controls can be more economically attractive in some cases
Rich Reagent Injection (RRI)

- Staging creates hot, fuel rich lower furnace
- NH$_3$/urea accelerate the rate of NO$_x$ reduction under reducing conditions
- Insignificant NH$_3$ slip
- Developed by REI and EPRI
- Fuel Tech, CCA, and FERCo are licensed implementers
Advanced Layered Technology Approach (ALTA)

**SNCR**
- Enhanced by reduced stratification

**Overfire Air**
- Rapid mixing with relatively unstratified combustion products

**Rich Reagent Injection**
- Urea accelerates rate of NO\(_x\) reduction

**Homogenizing Burners**
- Limited stratification
- Lower furnace SR near optimum
ALTA in Cyclones

- Inherent Advantages for Cyclones
  - Partial combustion in cyclone barrels results in a fuel-rich, relatively well mixed, lower furnace
  - Relatively small furnaces accommodate effective reagent and overfire air mixing

- ALTA installed in 16 cyclone boilers in the US
  - Single and opposed wall-fired boilers
  - 50 MW – 500 MW units
  - CFD based design is critical
ALTA Performance
488 MW Opposed Wall Cyclone

NO\textsubscript{x} (OFA+RRI)
0.16 lb/MBtu

RRI Flow Rate

NO\textsubscript{x} (ALTA)
0.12 lb/MBtu

SNCR Flow Rate

NO\textsubscript{x}
0.23 lb/MBtu

445 MWg
ALTA Economics
50 MW Target Wall Cyclone

• ALTA is an economically attractive option for NO\textsubscript{x} control
  – ALTA installed capital cost = $32.5/kW
  – ~85% lower capital costs vs. SCR
  – ALTA operating costs at Summer 2008 urea prices ($1.76/gal)
    • ~ $900 - $1200/ton NO\textsubscript{x} removed (0.7 lb/MBtu baseline)
    • ~55% NO\textsubscript{x} Reduction

• Full load control strategy
  – Fixed OFA damper positions
  – Reagent flows: 60 gph for 55% reduction target (NSR~1.7)
ALTA in PC Units

• DOE funded program to evaluate ALTA approach in pulverized coal units

• Major components
  – Deep staging
  – Optimized burner design for deep staging
  – RRI in fuel-rich zone

• Pilot-scale tests
  – U of Utah
  – 5 MMBtu/hr furnace

• CFD of pilot-scale tests and full-scale unit
Pilot-scale Testing

- PC with conventional low NOx burner design
- NOx as low as 38 ppm, (0.04 lb/MMBtu) under extended residence time
- 79% reduction from RRI at SR$_b$ of 0.85
- Reagent enhancement of NOx reduction kinetics irrelevant at SR$_b$ < 0.75
Rapid Homogenization Burner

Pilot Scale

Conventional LNB

“Homogenizing” Burner

Better mixing / reduced stratification
Impacts of Rapid Homogenization Burner

Pilot Scale

![Graph showing the effect of Burner Stoichiometric Ratio (Staging) on NO levels. The graph includes lines for MRRIB NSR = 0, MRRIB NSR = 2, LNB NSR = 0, and LNB NSR = 2. The dNOx is 30%.]
Full-scale Conceptual Implementation

- 180 MW Front-wall-fired boiler using Eastern Bituminous coal
- Previous CFD-based modeling and site testing of RRI indicated < 10% NOx reduction
- Simulations with homogenizing burners to:
  - Optimize burner stoichiometry
  - Guide reagent injection strategy
Impacts of “RRI” Burner
180 MW Boiler

Baseline SR=0.90
RRIB_SR=0.70
RRIB_SR=0.80
RRIB_SR=0.90

The “RRI” burner homogenizes the lower furnace flue gas
The “RRI” burner significantly improves RRI performance and leads to an overall NOx reduction of 36%
Summary

• ALTA in cyclone units
  – Implemented in cyclone boilers as a cost effective alternative to SCR
  – Commercially installed and operated in 16 cyclone boilers to-date

• ALTA in PC units
  – Pilot-scale testing and CFD modeling of a 180 MW coal boiler show that RRI can produce significantly lower NOx emissions than conventional LNB approaches
  – RRI performance in PC units relies on LNB technology optimized for deep staging

• ALTA leverages use of common reagent equipment in RRI and SNCR processes

• RRI, a key ALTA component, is an EPRI owned technology