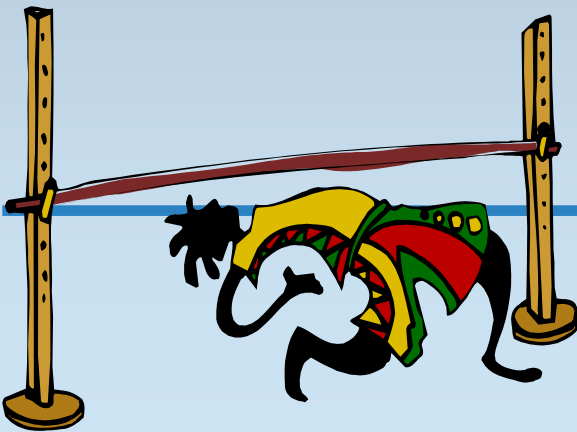


# Doing the Low-NO<sub>x</sub> Limbo: How Low Can You Go?

**Presented Last Year  
at the  
Reinhold NO<sub>x</sub> Round Table  
Akron, Ohio**



# Bump & Grind: How Mill Operation Can Help NO<sub>x</sub> Compliance

Presented at the Reinhold NO<sub>x</sub> Round Table  
Charlotte, NC

By Steve Johnson  
Quinapoxet Solutions

23 January 2005



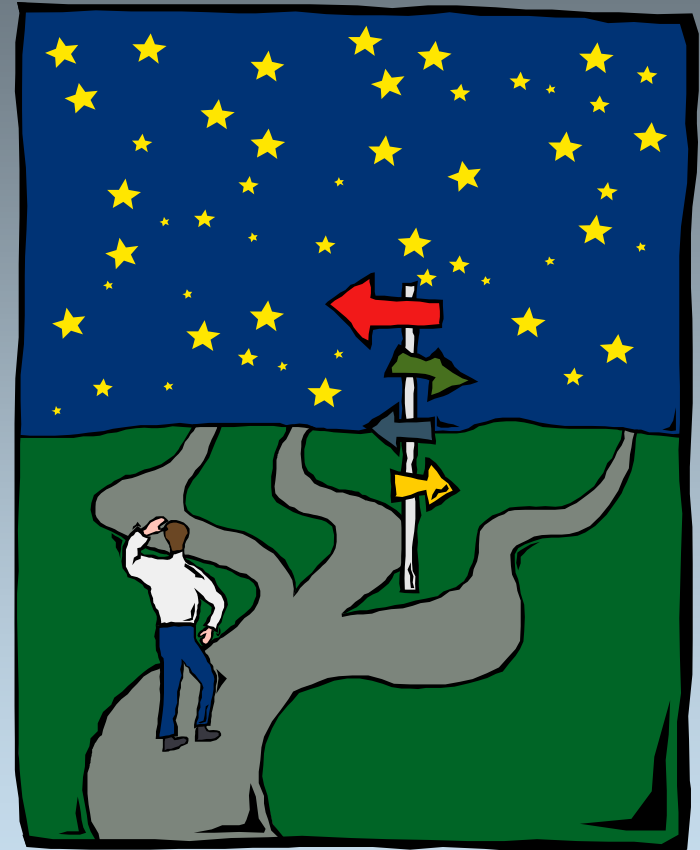
# Workshop Introduction

- NO<sub>x</sub> Reduction Review
- Mill Operating Strategies
- Equipment Options
- Ways to Make Your Life Easier!



# Ways to Reduce NO<sub>x</sub> during Combustion

- ☺ **Tuning your Low-NOx Combustion System**
  - ☺ Increased Fuel N release
  - ☺ High temperature reducing zone
  - ☺ Reduced stoichiometric ratio
  - ☺ Reduced excess air
  
- ☺ **Removing operational constraints**
  - ☺ Opacity
  - ☺ LOI/CO
  - ☺ SH/RH temperatures
  - ☺ Scanner failure



# Low-NO<sub>x</sub> Burners

Control air-fuel mixing

Create locally fuel-rich regions in flame

Lean out gradually



# Next Generation Low-NO<sub>x</sub> Burners

## Advantages:

Simple to replace burners

20-50% NO<sub>x</sub> reduction

First step to compliance

## Disadvantages:

LNB alone may not achieve compliance.

Usually need better air-fuel distribution.



# LNB Limits

- **Not many adjustments available**
  - Coal flow distribution
  - Airflow distribution
  - Excess air
  - Primary air
- **Limits**
  - CO/LOI
  - Flame liftoff
  - Flame impingement



# Low-NO<sub>x</sub> Burners with Overfire Air (OFA)

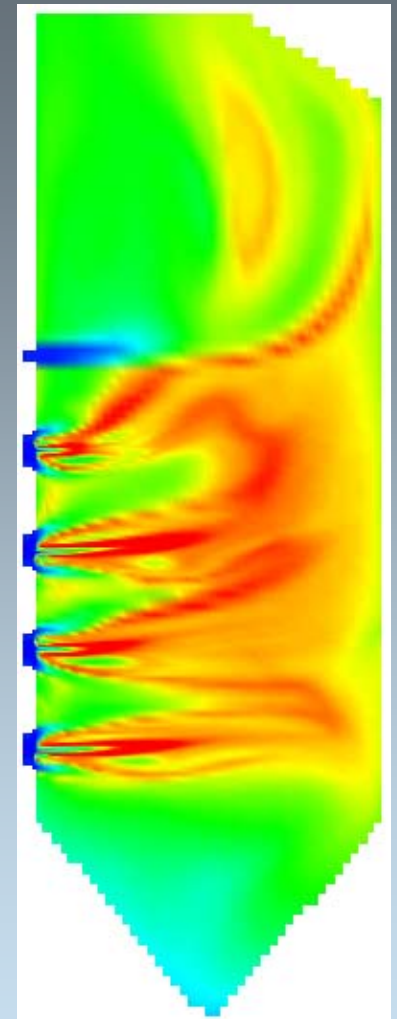
## How it Works:

- Redirect windbox air away from burners to overfire air ports
- Makes flames more fuel-rich
- Combustion completed higher in furnace



# Staged Combustion

- **Biased firing**
  - Lower burners fuel-rich
  - Upper burners fuel-lean
- **OFA**
  - All burners fuel-rich
  - Add air above burner zone
- **Reburning**
  - Add fuel above burners
  - Add air downstream of fuel addition point



# Conventional Staging

## Advantages:

Lower NO<sub>x</sub> than LNB alone.

Achieve 0.15 lb/MBtu NO<sub>x</sub>  
with PRB coal in many  
furnaces

## Disadvantages:

Operating issues may  
compromise effectiveness.

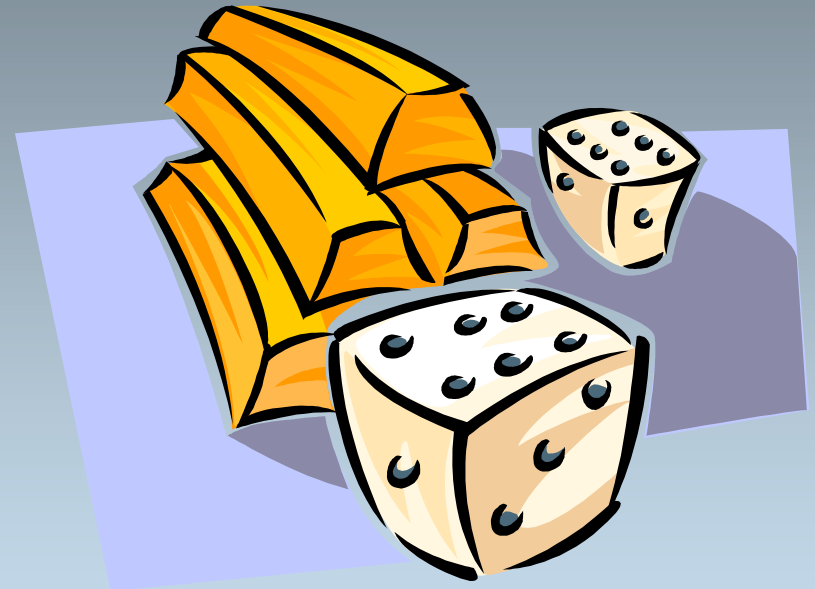
Need superior air-fuel  
distribution.



# Issues Limiting Staged Combustion

## Risks include:

- Increased LOI/CO
- High steam temperatures
- Flame impingement
- Flame stability (scanners)
- Higher opacity



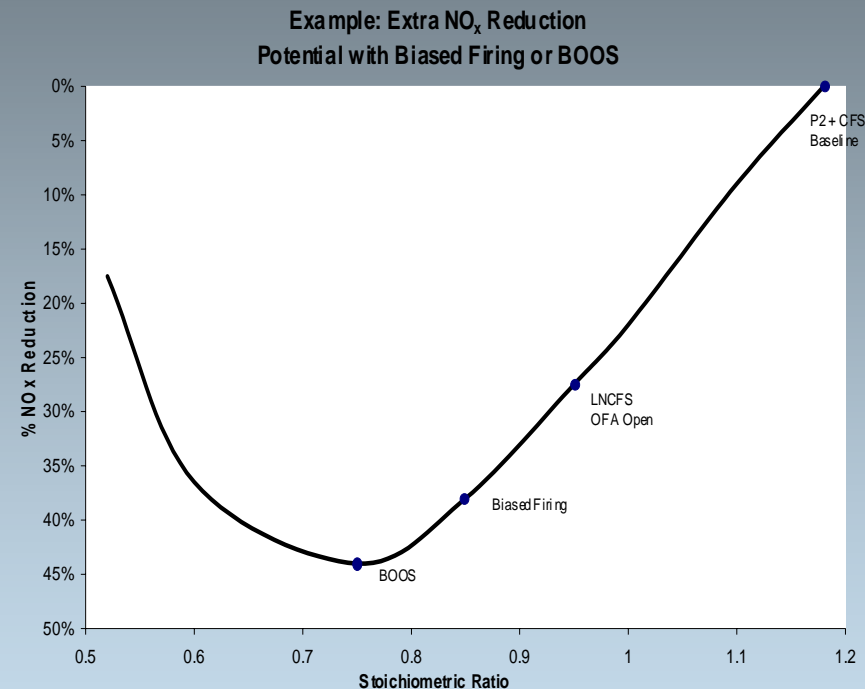
# OFA Variations

- CCOFA
- SOFA
- ROFA
- BOFA



# Parameters that Reduce NO<sub>x</sub>

- SR in lower furnace is primary variable
- Other factors include:
  - flame front position
  - flame temperature
  - temperature at OFA elevation
  - number of OFA elevations
  - excess air



# Mill Operation as a “NO<sub>x</sub> Trim”

- Coal fineness
- Coal flow distribution
- Primary airflow
- Primary air distribution
- Mill capacity



# Coal Fineness

- **Impacts:**
  - Finer coal  $\Rightarrow$  more surface  $\Rightarrow$  volatile N release
  - If flame is reducing,  $\text{NO}_x$  is lower
  - LOI and CO will also generally be lower
  - This may allow further  $\text{NO}_x$  reduction by lower excess air.
- **Adjustments:**
  - Classifier settings
  - Reduced airflow
  - Wider ring gap
- **Caveat: usually reduces throughput!**



# Potential NO<sub>x</sub> Reduction

- Depends on combustion system
- Nominally about 10%
- Can be improved with combustion tuning



# Coal Flow Distribution

- **Desired conditions:**
  - Uniformity within a mill group of burners
  - Bias coal to lower burners
- **Impacts:**
  - Uniformity reduces CO threshold → lower excess air.
  - Bias allows staging for lower NO<sub>x</sub> emissions.
- **Adjustments:**
  - Riffle boxes
  - Coal line gates
  - Primary airflow
  - Coal feeder speed



# Potential NO<sub>x</sub> Reduction

- Reduced excess air can achieve 10-20% NO<sub>x</sub> reduction.
- Biased firing can achieve an additional 10-20% reduction.
- Realistically, coal flow control is difficult.
- Only 10-20% total NO<sub>x</sub> reduction is sustainable.



# Primary Airflow Distribution

- Coal usually follows the air.
- Per-burner airflow measurement can help maintain  $\text{NO}_x$  reductions.
- Per-burner coal-flow measurements also available.
- Reducing primary airflow also allows better burner tuning.



# Importance of Mill Capacity

- **Determines how much you can bias coal flows to reduce NO<sub>x</sub>.**
- **Coal properties are important.**
- **Mill maintenance is critical.**
- **Trade-off between capacity and fineness.**
  - Push throughput to bottom mills
  - Coarser coal
  - Increased ash LOI (depends on furnace size)
  - Value of NO<sub>x</sub> credits vs. ash sales.



# Possible Mill Upgrades

- Mill conversions
- Dynamic Classifiers
- Rotating Grinding Zone



# Mill Conversions

- **Upgrade older designs**
  - E.g., E-mill to EL-mill (B&W)
  - Main advantage: reduced primary airflow for better LNB performance
- **Replace worn internals**
- **Can achieve 5-10 percent NOx reductions**
- **Main advantage is better reliability**



# Dynamic Classifiers

- **Classifier** is a device that separates coarse and fine coal, allowing fine coal to pass, while rejecting the coarse coal for regrinding
- **Dynamic Classifier** is a device with an inner rotating cage and stationary outer vanes, which provides centrifugal and impinging classification



# How it Works

- Enhancement of grinding performance is achieved by returning coal to the grinding zone, thus:
  - Increasing fineness and reducing coarse particles
  - Increasing pulverizer capacity
  - Increasing both fineness and capacity



# Classifier Performance Improvements

- Steeper fineness distribution slope angle (Rosin-Rammler Plot)
- Reduced amount of superfine and coarse material
- Reduced internal product recirculation
- Reduced over-grinding, wear, power absorption and mill vibration
- Reduced differential pressure across the mill and reduced gas flow



# Effect on NO<sub>x</sub>

- Site-specific
- Reduced excess air with LNB
- More capacity = more staging
- Typically 10-20% reduction
- Data?



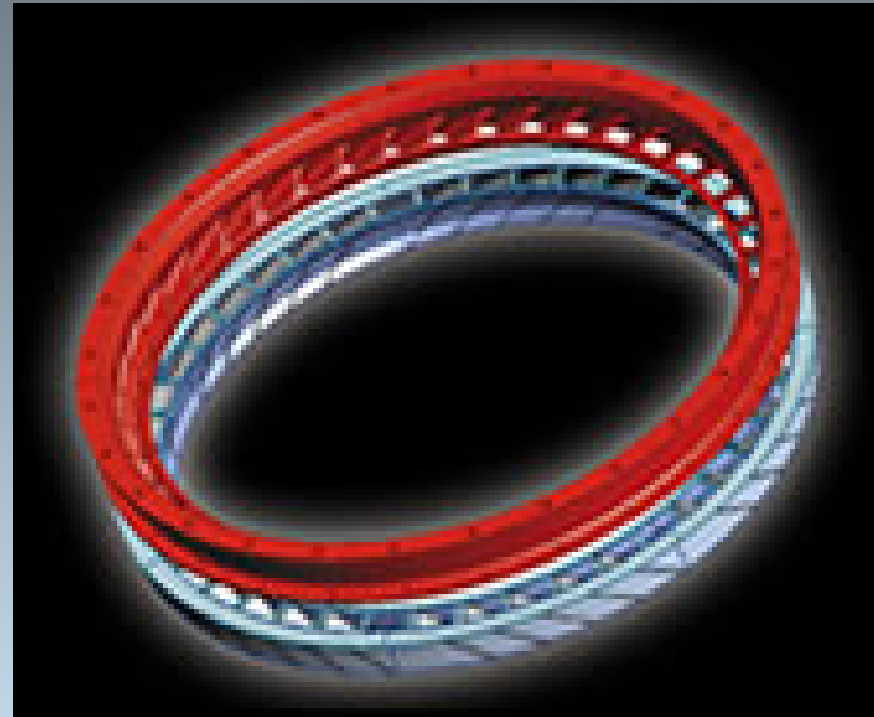
# Rotating Grinding Zone

- The Technomics Rotating Throat incorporates a venturi effect.
- The throat's converging-diverging nozzle converts pressure to velocity, blowing the coal back into the working zone of the pulverizer without blowing the rock back or clogging air ports.
- The Rotating Throat's high pressure drop throat helps to increase air speed without increasing primary mass air flow.



# How it May Reduce NO<sub>x</sub>

- Enhanced classifier performance and increased fineness
- A reduction of primary air without sacrificing pulverizer performance
- When you lower the primary air, you reduce NO<sub>x</sub> formation.



# Status

- 1.85:1 PA-coal ratio
- No NO<sub>x</sub> data available
- Expect 10-20% reduction
- Currently available for MPS mills



# How do we make life easier?

- Layered technologies for low  $\text{NO}_x$  are hard to control
- Don't fly blind!
  - Monitor and control LOI
  - Know your FEGT
  - Integrate with combustion controls
  - Per burner coal control
  - Airflow measurement and control
  - “Flame Doctor”

