John Zink Overview

- John Zink Company Overview
- Markets Served
- TODD Products & Technologies
- Case Studies

Research and Development Facility

- Largest combustion test facility in the world
- 14 Full-scale furnaces
- 1 Dedicated to Duct Burners
  - 1 Dedicated to Boiler Burners
- 2 Lab-scale furnaces
- Flare testing pad
- Firing capabilities up to 150 MM Btu/hr
- Ability to blend and simulate a wide variety of liquid and gas fuel compositions

John Zink Worldwide

- Sales offices and independent representatives throughout the world
Market Segments Served

- Chemical/Petrochemical
- Pulp & Paper
- Food & Beverage
- Facilities, Universities, Hospitals
- Marine
- Manufacturing
- Independent Power Producers
- Utilities - Electric Generating Plants

Methods of NOx Formation

Thermal NOx (Zeldovich Mechanism) is a function of:

\[ [NO] = A e^{- \frac{b}{T(N_2)}} \frac{[O_2]}{dt} \]

- Peak flame temperatures (> 2500 deg F) which breaks apart N2 molecules
- Available oxygen to bond with and form NOx
- Time to allow the reaction to occur
- ~ 80% of the NOx from a natural gas burner

Methods of NOx Formation

Fuel NOx formed from nitrogen contained in the fuel

- 0% of NOx in natural gas firing (no FBN)
- ~ 50% of NOx in #2 oil firing (0.02% FBN)
- ~ 80% of NOx in #6 oil firing (0.30% FBN)
Methods of NOx Formation

Prompt NOx (Fenimore Mechanism) forms in sub-stoichiometric regions by:

- Rapid reaction of fuel radicals with atmospheric nitrogen
- HCN and NH3 are formed as intermediate species
- Completed combustion causes these molecules to convert to NOx

~ 20% of NOx from a natural gas burner

Boiler Burner Design Considerations

- Boiler type/design
  - Packaged
  - Field erected
  - Single burner
  - Multi-burner
- Burner Zone Heat Release (BZHR)
  - Furnace refractory
  - Combustion air temperature
- Fuel composition
  - Fuel bound nitrogen
  - Flame temperature

NOx Reduction Methods

- Flue gas recirculation (FGR)
  - Forced
  - Induced
- Steam or water injection
- Fuel-air staging
  - Staged combustion burner designs
  - Furnace staging
  - Over fire air (OFA)
- NOx ports
- Gas fuel conditioning (FIR)
- Other

NOx Control Technology

Staged Combustion Burner Design

- Staged air enters flame to quench burner

TODD Low NOx Burner Design Features

- Gas staging techniques
  - Gas injector design & orientation
- Oil staging techniques
  - Atomizer design & spray patterns
- Flame stabilization techniques
  - Swirler design & orientation
- Air staging
  - Primary, Secondary, & Tertiary Air locations and distribution
**TODD Advanced Low NOx Burners**

- Natural Gas / Propane
  - 20 to 30 ppm
- Refinery Gases
  - 20 to 50 ppm
- Amber 363 Oil (0.002 % FBN)
  - 30 to 40 ppm
- #2 Light Oil (0.02 % FBN)
  - 50 to 80 ppm
- #6 Heavy Oil (0.3 % FBN)
  - 200 to 300 ppm

**TODD Ultra Low NOx Burner**

- Reducing NOx Where It Starts
  - Rapid Mixing eliminates fuel rich regions that form prompt NOx
  - Use of FGR or Excess Air reduces peak flame temperatures that form thermal NOx
  - By incorporating
    - A radically different gas injection and mixing system
    - Proven burner geometry to maintain an extremely stable flame

**TODD Products and Technologies**

- Variflame
- Variflame II™
- Dynaswirl-LN®
- RMB™
- COOL Technologies™
- LDRW Duct Burners

**Variflame Single Burner Applications**

- Industry leader for single burner applications
- Predictable performance
- NOx emissions as low as 15 ppm with FGR
- Low VOC, CO, and particulate emissions
- Capacity range: 30 to 400 million BTU/hr per burner
- High combustion efficiency
- High turndown ratios: 8:1 on oil and 10:1 on gas

**Variflame II™**

The New Standard in No-FGR Performance

The Variflame II is available for package boiler applications with burner heat inputs up to 150 million BTU/hr and offers the following benefits:

- Sub-30ppm NOx on natural gas without using FGR using COOL flame Technology
- Low NOx firing of light or heavy oils using COOLflame Technology
- Low CO, VOC, and Particulate emissions
- Superior flame stability
- No increase in flame length
**Variflame II Principle of Operation**

- Mixing Venturi
- Injector Gas Flame
- Center Fire Gas Flame
- Recirculated Furnace Gas
- Combustion Air

**Rapid Mix Burner**

- Guaranteed Ultra Low Emissions Performance
  - Less Than 9 PPM NOx
  - Less Than 25 PPM CO
  - Less Than 3 PPM VOC
- Plus the added benefits of
  - Easy Installation and Start-up
  - Compact Stable Flame
  - No Moving Parts
  - Streamlined Permitting Tasks
  - Opportunities for Emission Reduction Credits

**Dynaswirl-LN Multi-Burner Applications**

- Heavy duty design for multiple burner applications. Stress relieved when required
- Predictable performance
- NOx emissions as low as 20 ppm with FGR, BOOS, or OFA
- Low VOC, CO, and particulate emissions
- Capacity range: 30 to 300 million BTU/hr per burner
- Low Excess Air Levels

**COOL Technologies**

- COOLfuel
  - Gas Fuel Conditioning
- COOLlife
  - Burner Modifications
- COOLflow
  - Air Flow Modeling
- COOLspray
  - Steam or Water Injection

**COOLfuel**

- Fuel Gas Conditioning
  - Introduction of flue gases or other inert gases into the fuel
  - Lowers the heating value of the fuel
  - The diluted fuel results in lower NOx
Benefits of Fuel Dilution over conventional FGR.

- Adding the flue gases to the fuel has a greater effect on NOx reduction than adding them to the combustion air.
- Lower flue gas flows are required to achieve the same amount of NOx reduction.

COOLspray

Injection of Steam or Water for NOx Reduction

- Lowers the peak flame temperature
- Reduces thermal NOx formation
- Impacts system efficiency = higher operating costs
- Still economical when compared to SCR or other back-end cleanup
- Effectiveness dependant on injection method (fuel, air, flue gas)
- Water injection effectiveness dependant on droplet size

COOLflow

Air flow is one of the most significant contributors to Combustion Performance and COOLflow modeling takes out the guess work

- Evens airflow distribution
- Improves air and FGR mixing
- Reduces vibration
- Increases capacity
- Lowers NOx, CO, & other emissions
- Lowers the amount of excess air required
- Increases efficiency

Case Studies
Rapid Mix Burner Retrofit Case Study

- 100,000 lb/hr D-type package boiler
- Natural gas fired
- Ambient combustion air
- 23 - 28% FGR
- NOx less than 8.5 ppm across entire load range
- CO less than 1 ppm across entire load range
- Excess O2 of 3.2 to 4.0%
- Boiler capacity increased to 110,000 lb/hr

COOLfuel

165 MW tangentially fired utility boiler retrofit (CS 117)

- Boiler Type: Combustion Engineering
- Boiler Size: 165 MW
- Steam Flow: 1,200,000 PPH
- Burner Type: CE Tilting Tangential
- # Burners/Boiler: 40
- Heat Input: 40 MMBtu/hr
- Comb. Air Temp: 540 deg F
- Fuel: Natural Gas
- NOx base: 132 ppm
- COOLfuel NOx: 33 ppm

COOLflow

- Real Models = Real Results (CS 108 & CS 112)
- 1/12 scaled replica of the combustion air & FGR system for a 330 MW Utility Boiler in Northern California
- 24 Burners & 12 Over Fire Air (OFA) Ports
- FGR supplied by 4 airfoil spargers
- Improved airflow distribution
- Increased FGR flow by 5%
- Increased OFA flow from 8 to 12%
- Along with the new Dynaswirl-LN burners this reduced NOx from 73 to 36 ppm

Now Available!

“The John Zink Combustion Handbook is a welcome addition to combustion literature...”
—Chemical Engineering Magazine, July 2001

Developing Clean Air Solutions for Planet Earth

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