Development and Evaluation of Low-NO_X Burners for Industrial and Utility Applications

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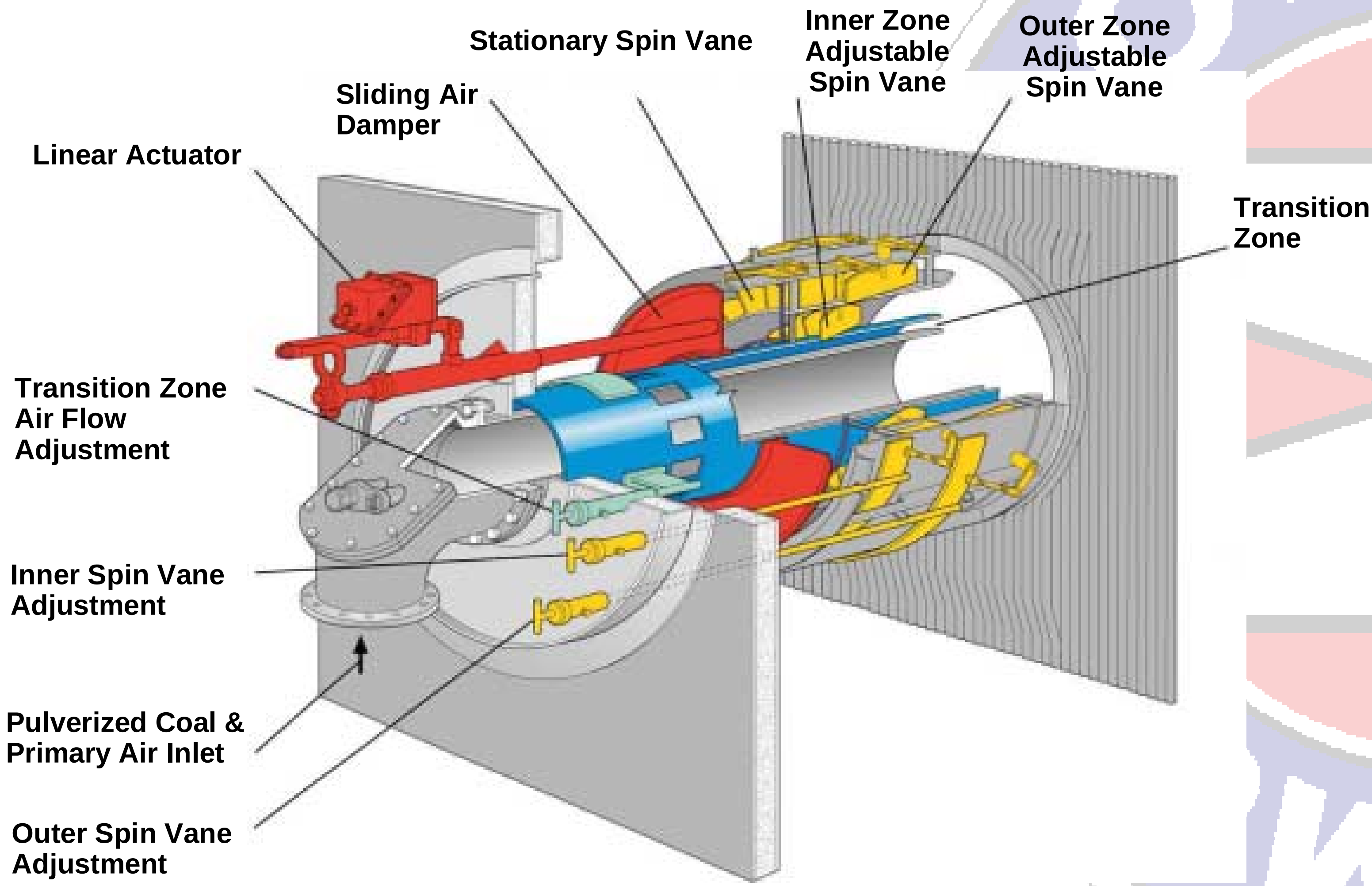
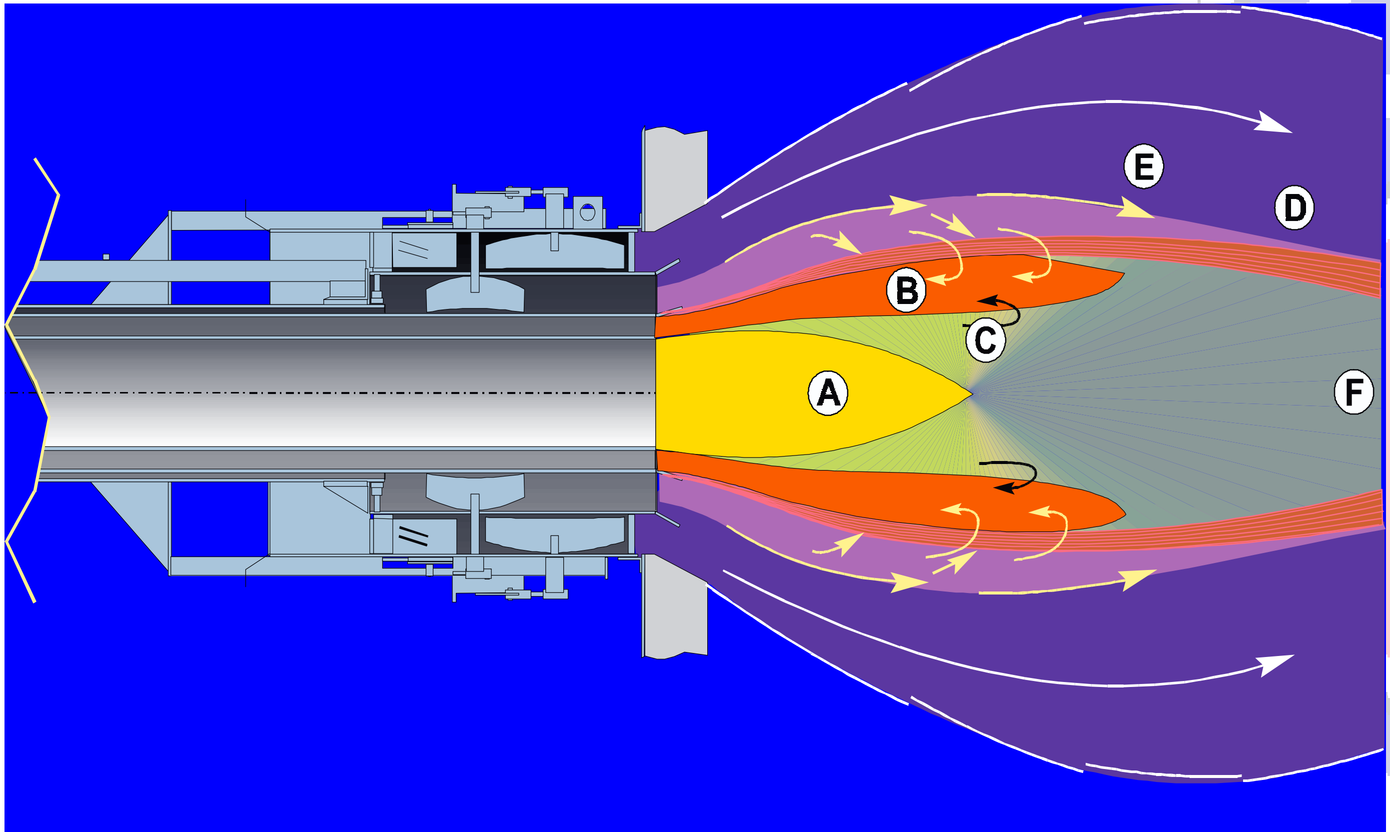
Current Low-NO_X Burner Design Principle

- Controlled separation and mixing of fuel and oxidizer
  - Release of fuel-N species in fuel-rich (low-O_2) combustion zones
  - In-flame NO_X destruction
  - Peak flame temperature suppression
- Proper air flow distribution
  - Fuel ignition and flame stability
  - CO and unburned carbon minimization

Ultra Low NO_X DRB-4Z™ Coal-Fired Burner



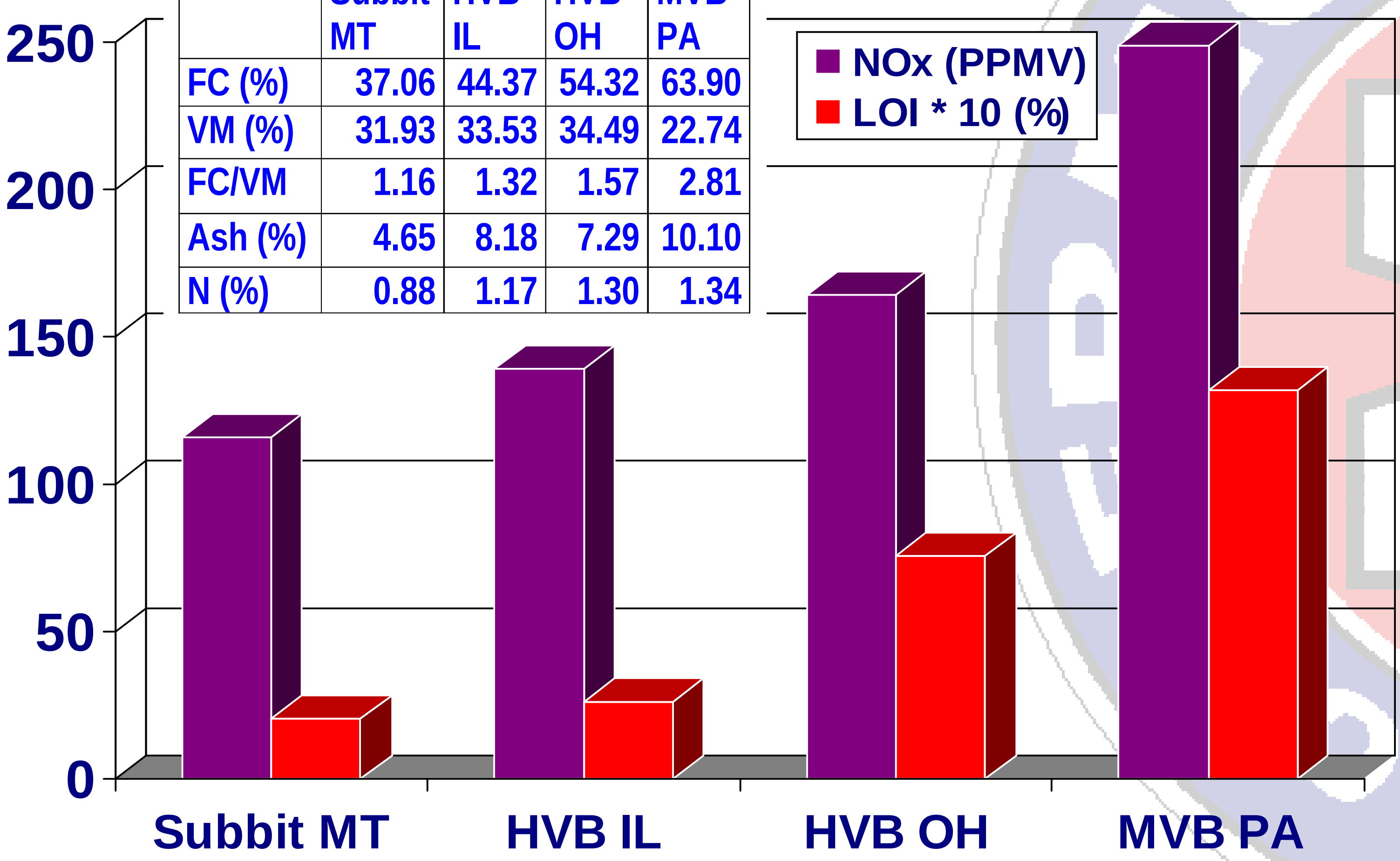
DRB-4Z™ PC Burner Flame Structure



- (A) Oxygen lean devolatilization
- (B) Recirculation of products
- (C) NO_x reduction zone
- (D) High-temperature flame sheet
- (E) Controlled mixing of secondary combustion air
- (F) Burnout zone

Coal Type Effect on NO_X and LOI for Standard DRB-4Z™ Burner at 17% Excess Air (no OFA) at 100 MBtu/hr

	Subbit MT	HVB IL	HVB OH	MVB PA
FC (%)	37.06	44.37	54.32	63.90
VM (%)	31.93	33.53	34.49	22.74
FC/VM	1.16	1.32	1.57	2.81
Ash (%)	4.65	8.18	7.29	10.10
N (%)	0.88	1.17	1.30	1.34



Our Vision of Next Generation Low-NO_X Burners

Self-diagnosing, self-tuning, low-NO_X burners with maximum combustion efficiency and minimum pollutant emissions performance

Motivation

- Coal-burning utilities will continue to produce most of the US electricity
- Efficiency and emissions goals are tightening
- Fuel switching can further impact combustion and emissions performance
- Passive burners have limited potential for improvement
  - Burner optimization by manual tuning is laborious
  - System instabilities can detune optimized burners
- Nonlinear flame diagnostics techniques have successfully identified non-optimum burners

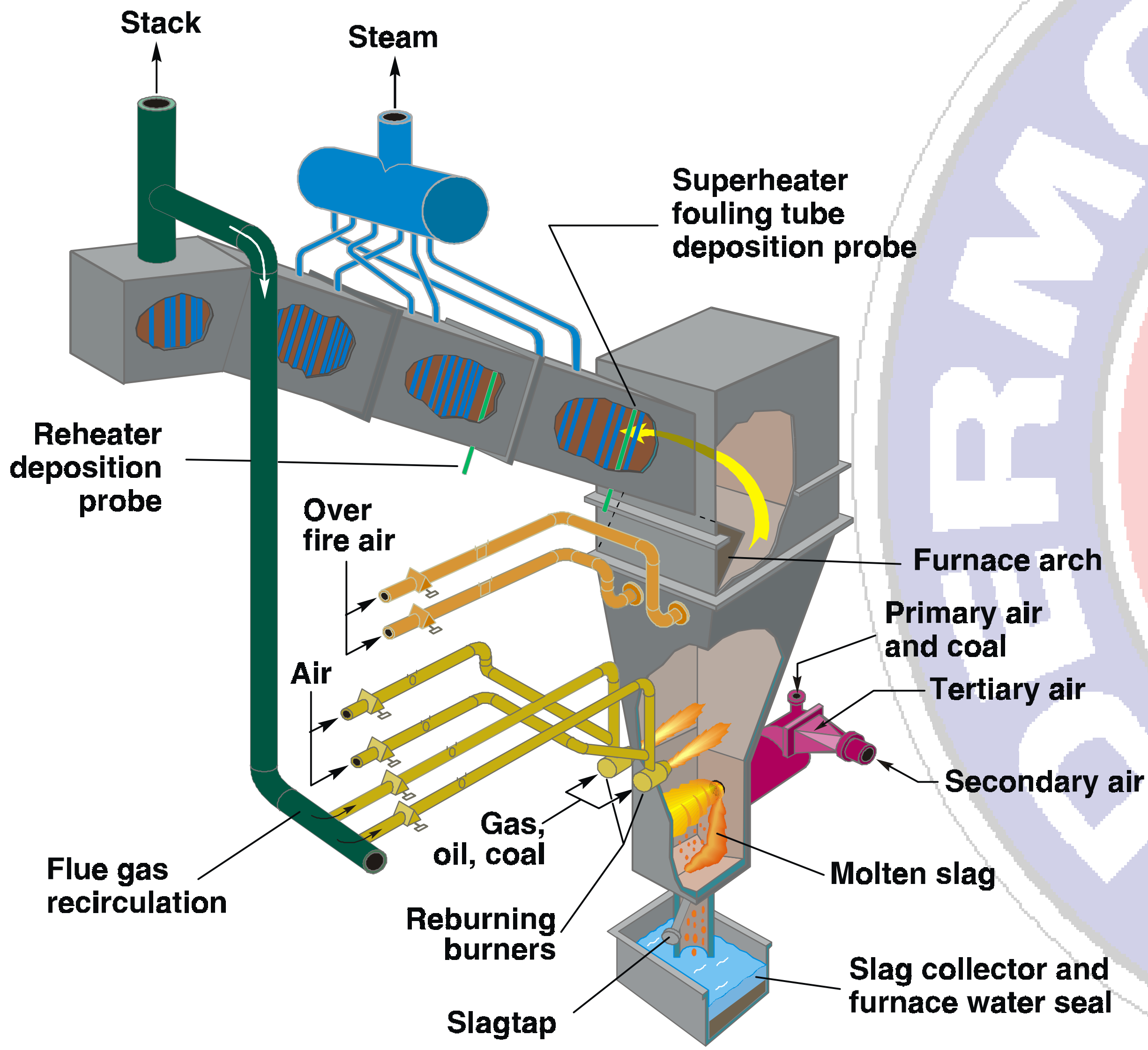
Key Elements in Next Generation Burner Design

- Innovative concepts based on sound fundamental principles to meet performance goals
- Non-intrusive sensors for flame structure scanning
- Flame signal processing and control algorithms
- Corrective action by control element based on feedback
  - Burner settings/operation adjustments
  - Closed loop control deployment

Approach

- Nonlinear dynamic combustion stability modeling
  - Capture of primary control parameters affecting flame structure
- Bench-scale feasibility tests
  - Flame response to major control inputs parameters
- Identification of control system requirements
  - Control elements, parameters, and algorithms
  - Flame structure sensors
- Prototype design and performance simulations
  - Component development and incorporation of control system
  - Numerical modeling of candidate concepts
- Pilot-scale testing
  - Performance verification and dynamic model validation for scale-up and commercial demo

$6x10^6$ Btu/hr Small Boiler Simulator



100x10^6 Btu/hr Clean Environment Development Facility