Investigation of Nitrogen Release during Pyrolysis in an Oxycombustion Process

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Overview

- NO_x overview
- Oxycombustion
- Experimental Methods
- CPD Code
- Results
- Conclusion

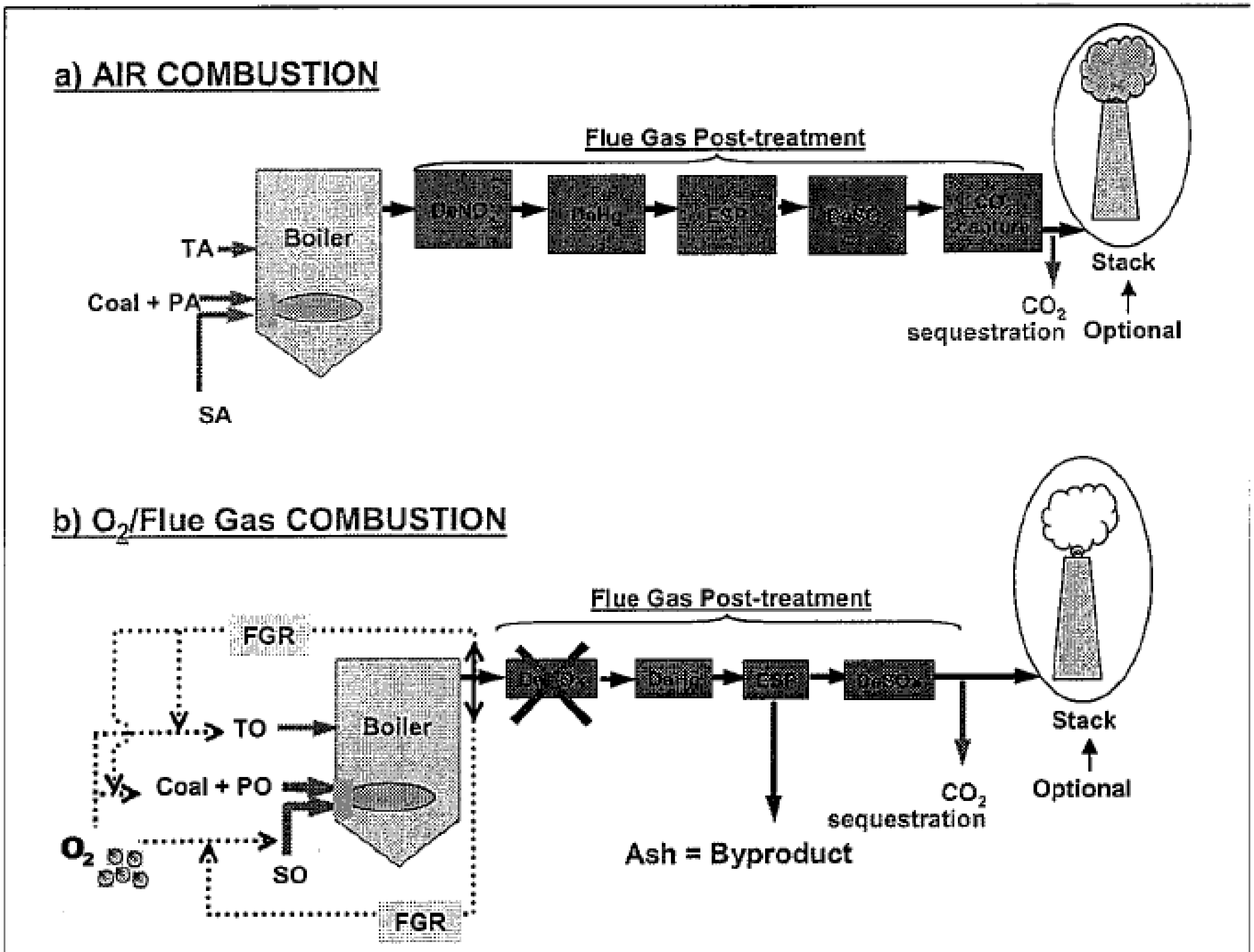
Pollution Control

- US Stationary Combustion source NO emissions
  - 1990 13.3 million metric tons CO_2 equivalent (mmtCe)
  - 2006 14.7 mmtCe
- Emission averages/limits
  - 0.5-0.6 lb/MBtu
  - 65% removal

NO_x Formation Mechanisms

- Thermal NO_x
  - Zeldovich mechanism
  - 5-25% in PC Boilers
- Prompt NO_x
  - <5% in PC Boilers
- Fuel NO_x
  - 70–80 % in PC Boilers
  - Affected by
    - Coal nitrogen content
    - Air to fuel ratio

Oxycombustion Power Plants

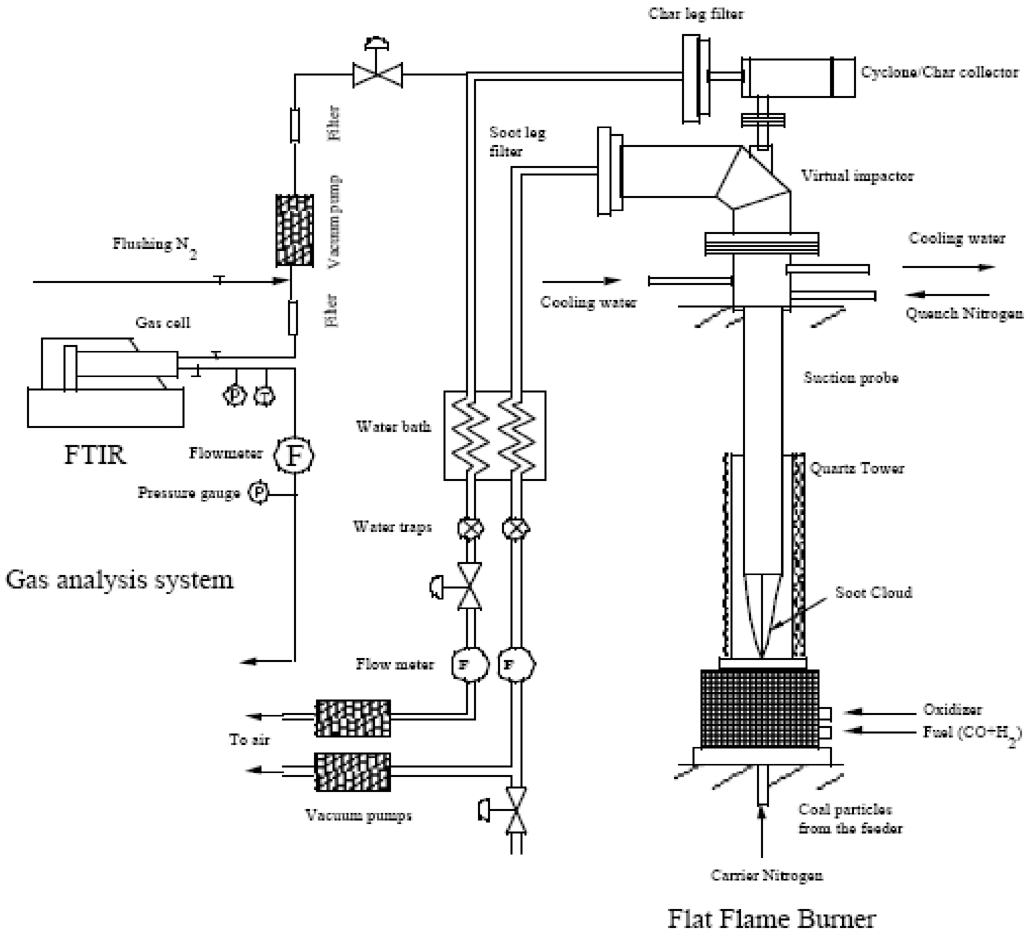


- From Chatel-Pelage, et al. Oxy-combustion in pulverized coal-fired boiler: a promising technology for CO 2 capture The 29th International Conference on Coal Utilization and Fuel Systems, Clearwater, FL, 2004.

How was the data obtained

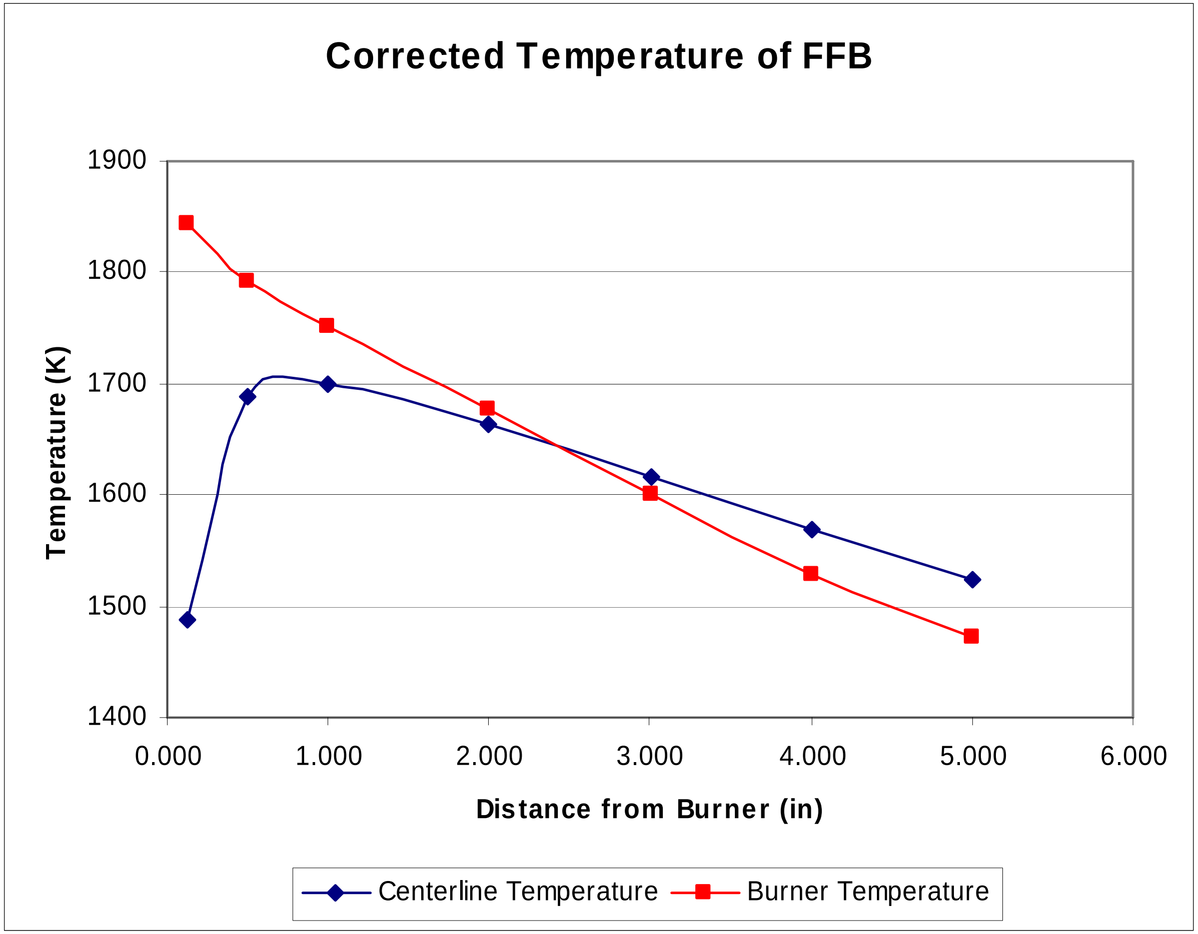
- Flat Flame Burner Oxyfuel Setting (2007)
  – Pyrolysis experiments at 100 K intervals
- Flat Flame Burner Nitrogen Settings (2001) – Haifeng Zhang
  – Pyrolysis experiments
- CPD Code
  – Models mass and nitrogen release

Flat Flame Schematic



- Dilluent switched from N_2 to CO_2 for Oxyfuel cases
- Feed rate about 1 gram/hr
- Simulates single particle affects
- Experiments had a residence time of 15 ms

Temperature Profiles



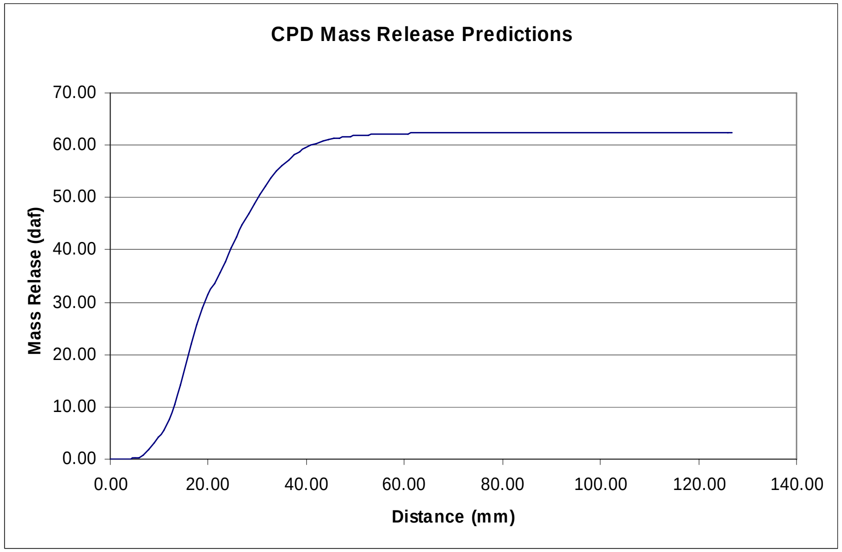
- 1700 K profile
- Adiabatic Flame Temperature of 1778
- Measured with type B thermocouple
- Temperature adjusted for radiation affects

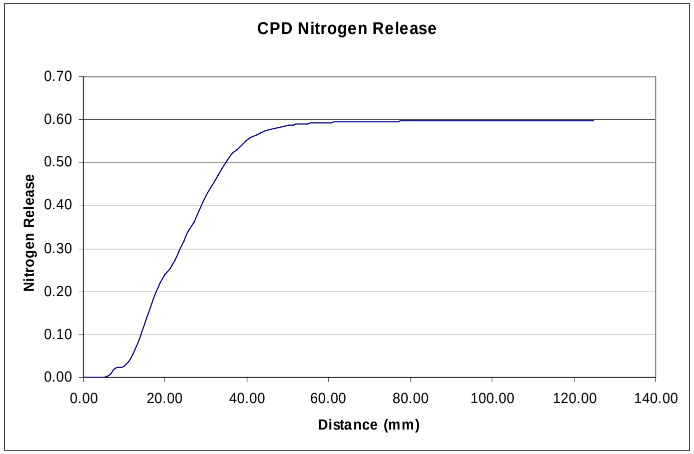
CPD Code I

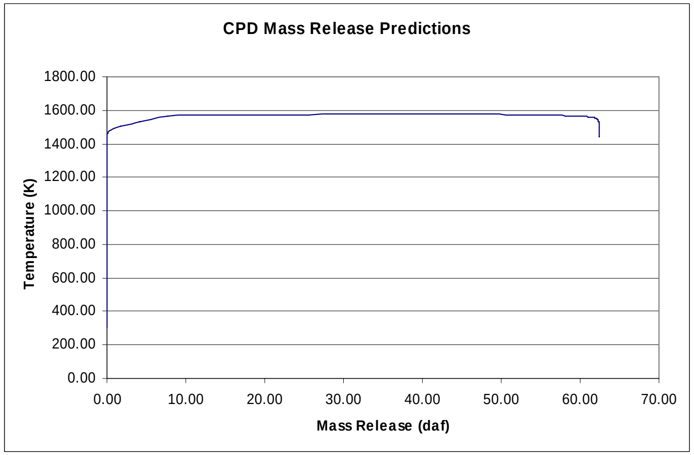
- Cpdcpnlg version modified by Perry (1999)
  - Calculates nitrogen release for tar, light gas
  - Models devolatilization based on chemical structure of parent coal
  - Uses C-13 NMR data

CPD Code II

Black Thunder 1600





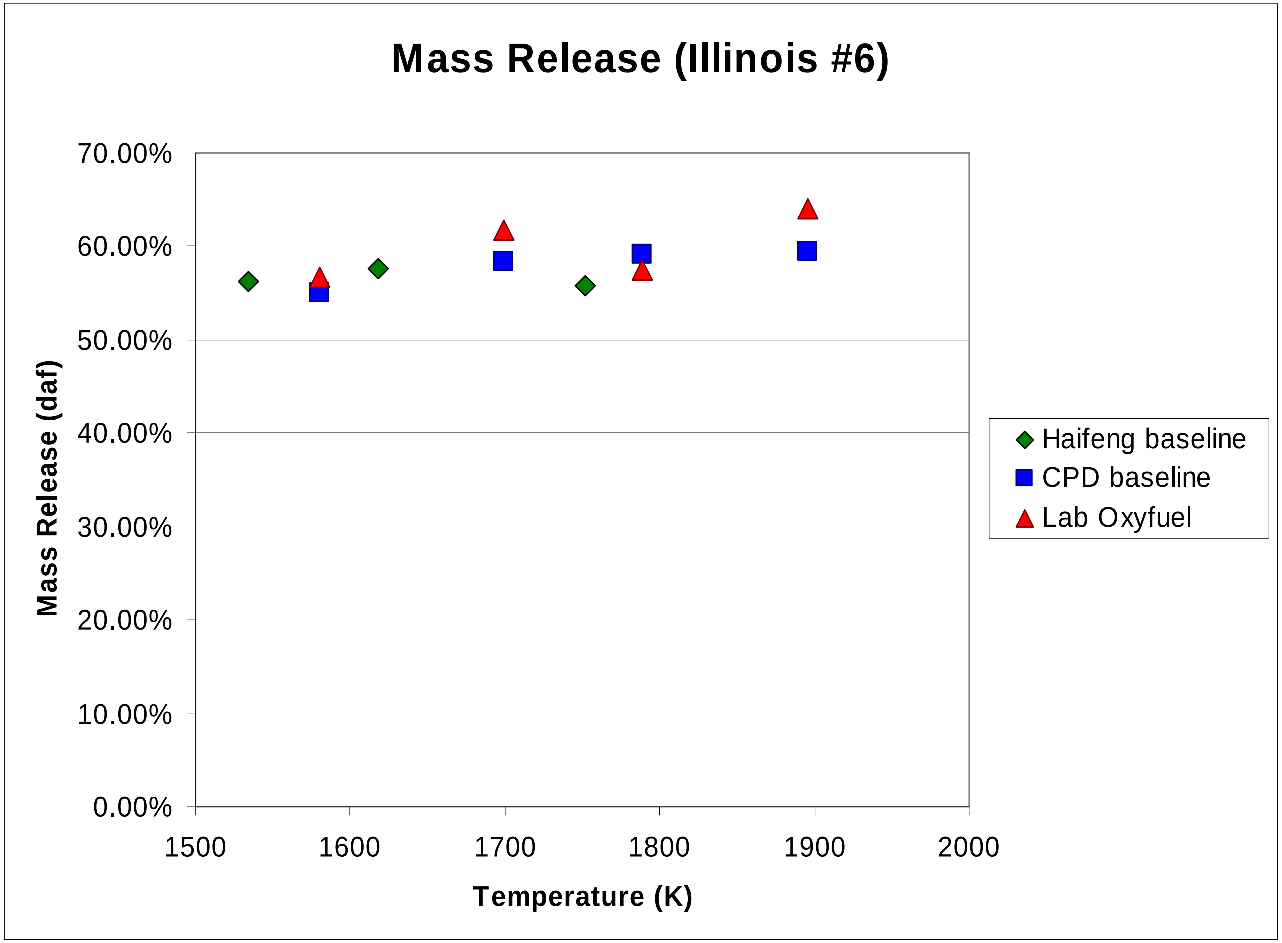


Mass Release - Calculation

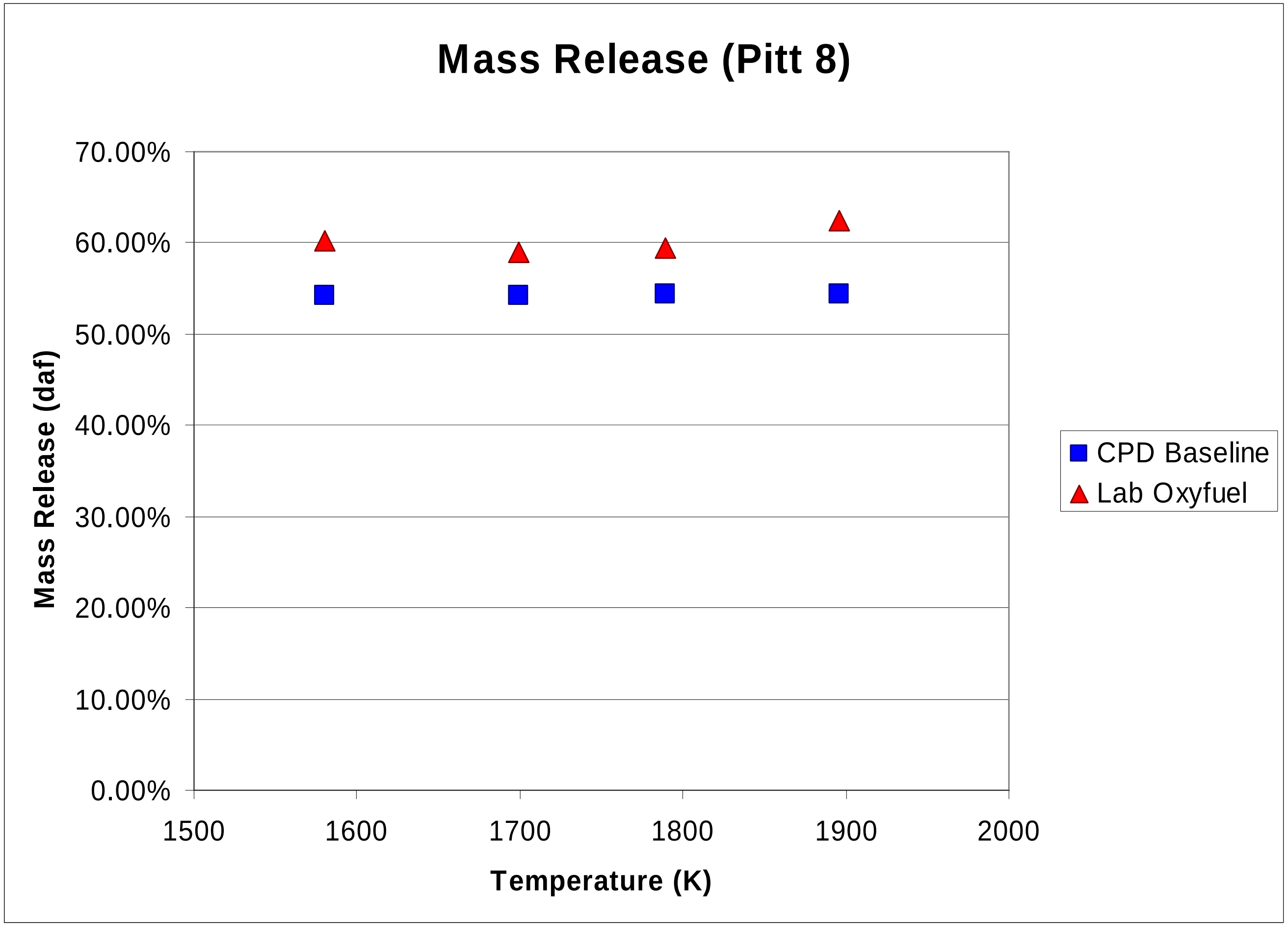
$$\frac{m}{m_o} = \frac{1 - \dfrac{x_{ele,coal}}{x_{ele,char}}}{1 - \dfrac{x_{ele,coal}}{x_{ele,ash}}}$$

- Mass release calculated using Elemental Tracer Analysis (ETA)
- ETA performed for Si, Ti, and Al
- Individual ETA calculated using equations on left, then averaged

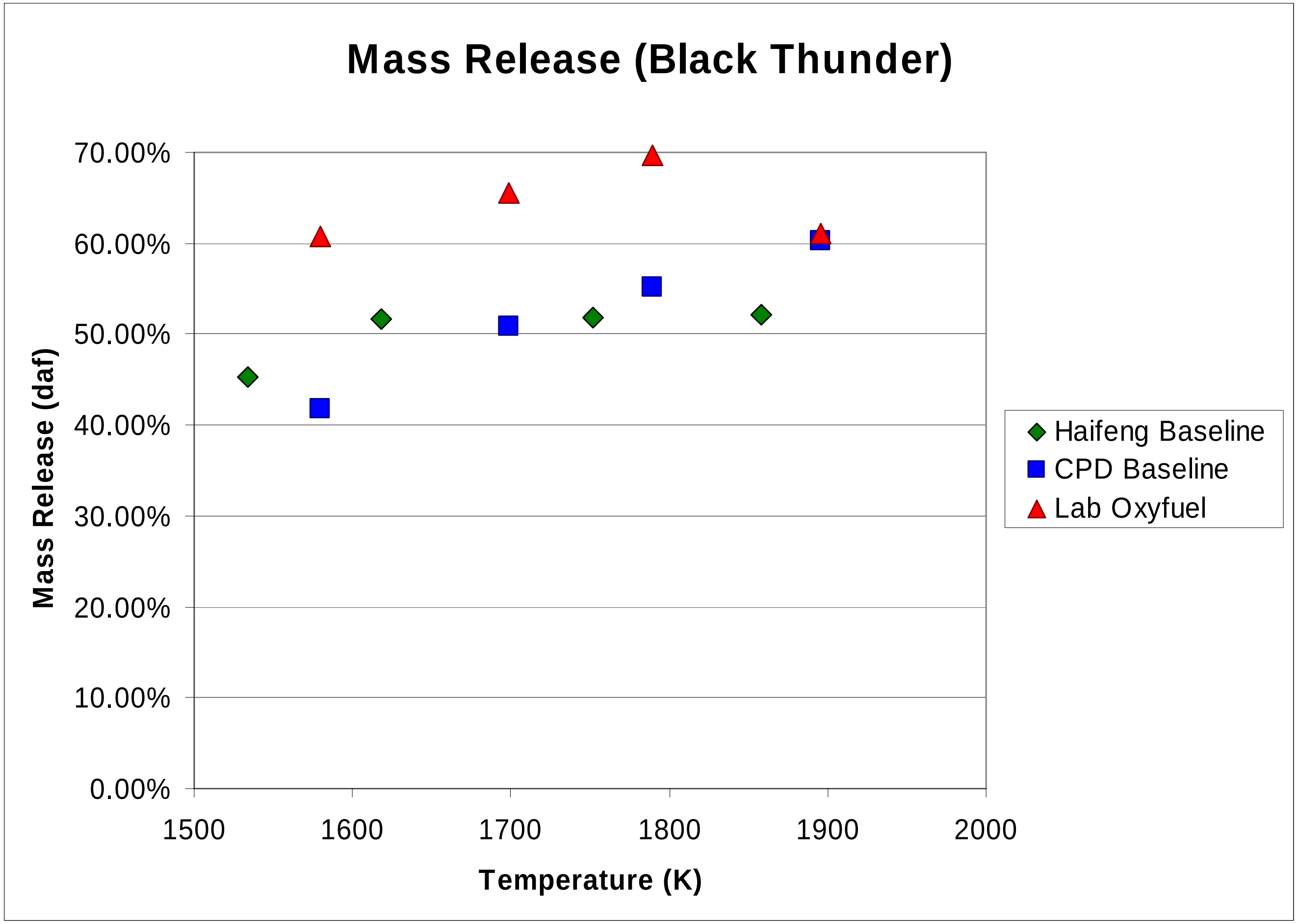
Mass Release - Illinois #6



Mass Release - Pittsburg #8



Mass Release – Black Thunder

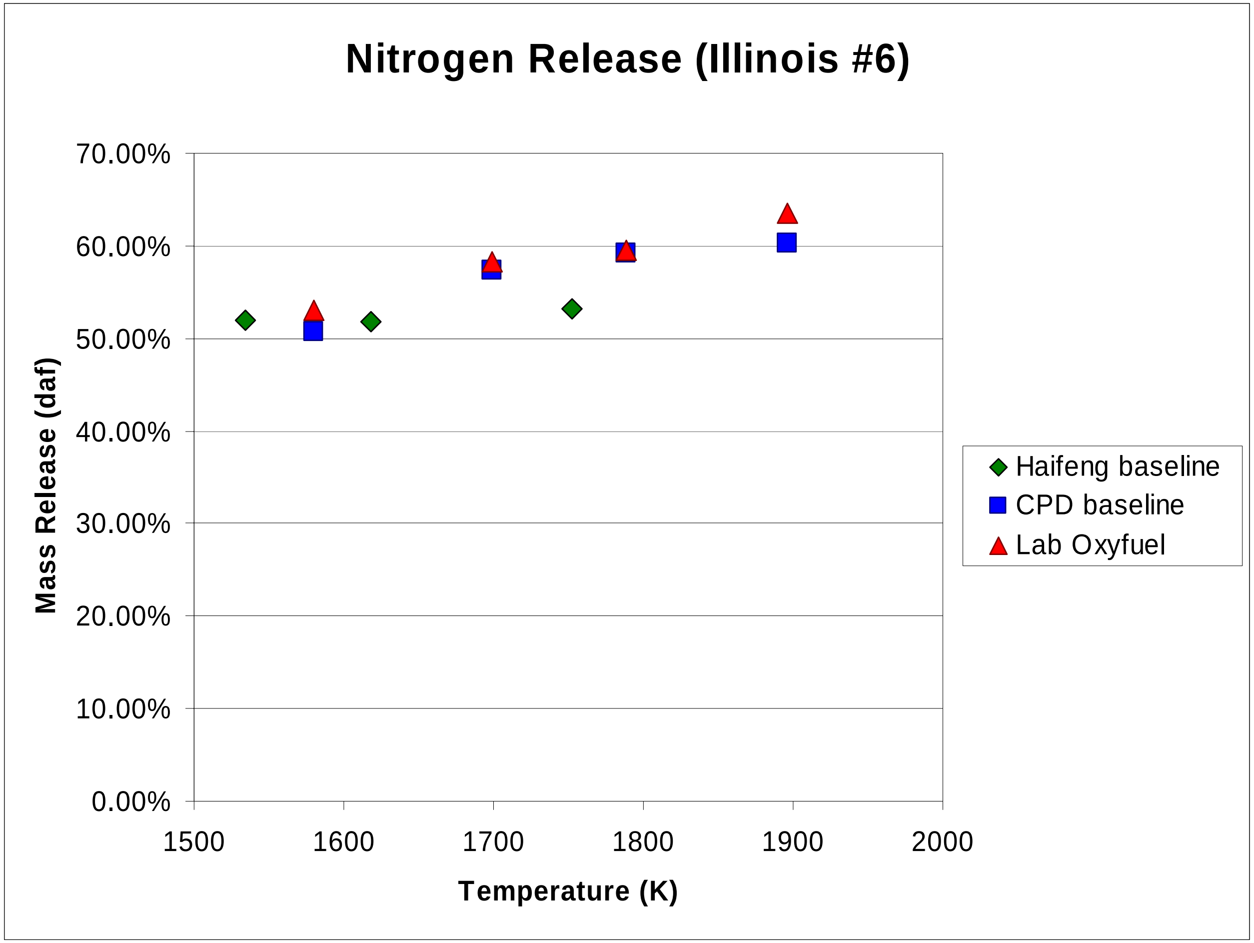


Nitrogen Release

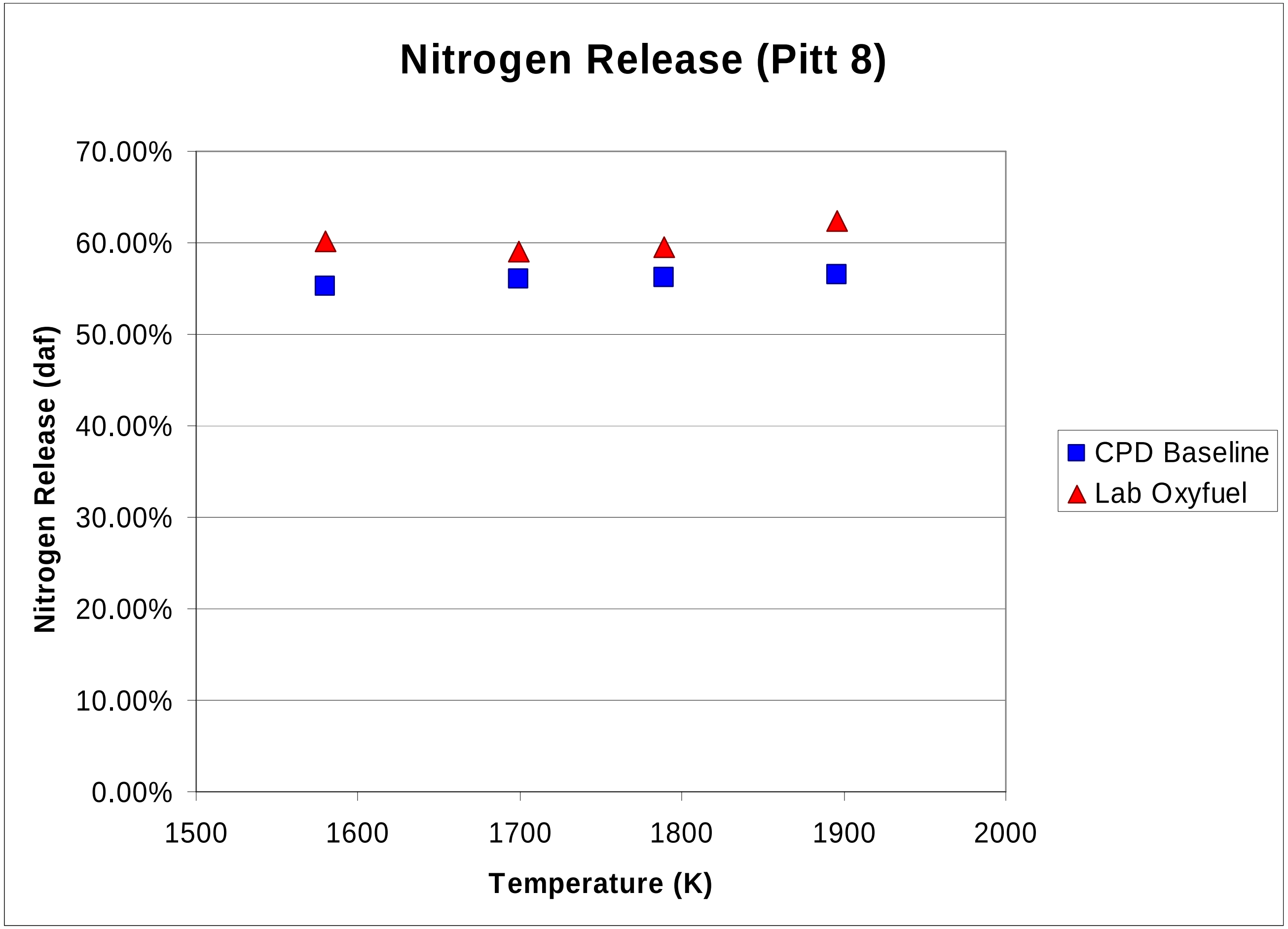
$$\%\text{ N release (daf)} = 1-\left(1-MR_{daf}\right)\left(\frac{x_{N,daf\ \ char}}{x_{N,daf\ \ coal}}\right)$$

	Uitimate Analysis		
	Illinois #6	Pitt #8	Black Thunder
Carbon	75.08	81.60	71.19
Hydrogen	5.55	5.79	5.30
Nitrogen	1.28	1.33	1.02
Oxygen (by difference)	15.33	7.23	21.91
Sulfur	2.77	4.05	0.58

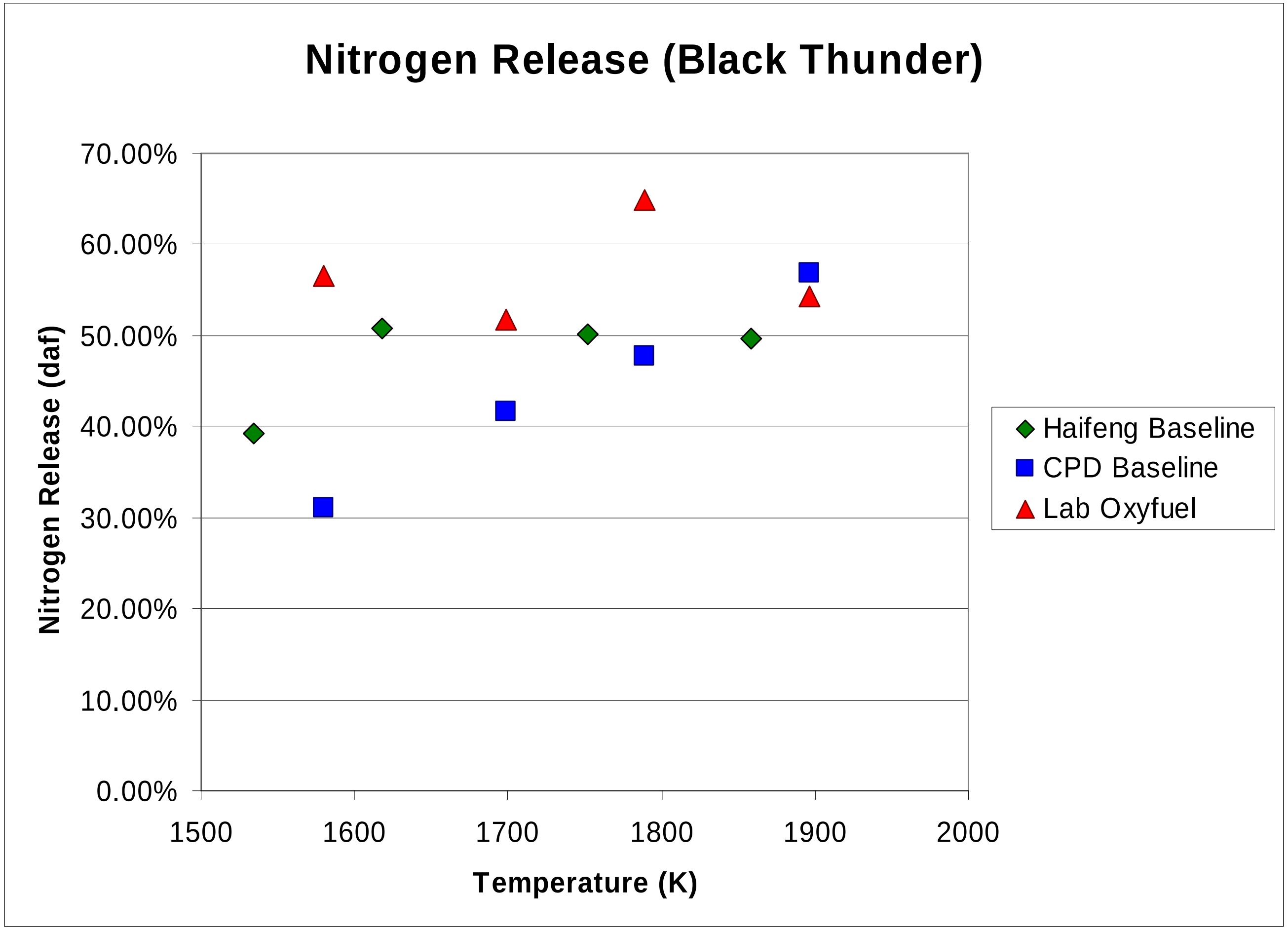
Nitrogen Release – Illinois #6



Nitrogen Release – Pittsburg #8



Nitrogen Release – Black Thunder



Conclusion

- There is a large motivation to eliminate NO_x through cheaper methods
- Oxyfuel has shown potential to reduce NO_x emissions in these ways
- No appreciable difference in mass release or N release observed in oxyfuel condition for the bituminous coals (Ill 6, Pitt 8)
- Increased mass & nitrogen release for sub-bituminous coal (BT) in the oxyfuel environment

Acknowledgements

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