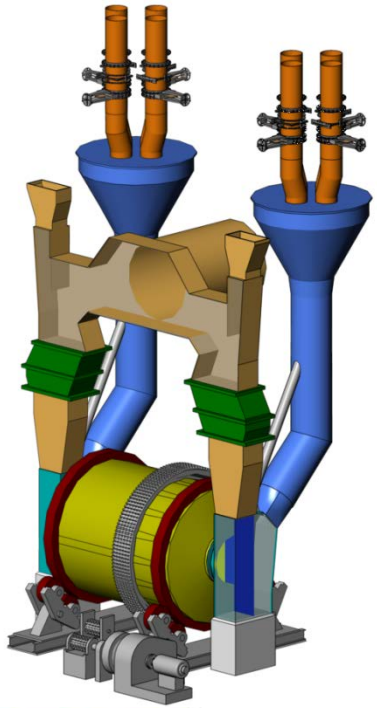
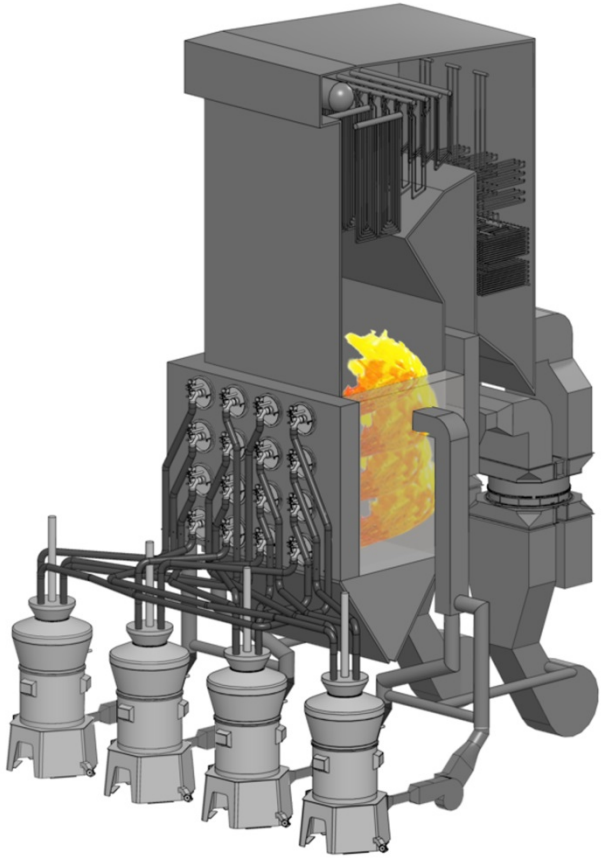
Pulverizer Performance and its Impact on Heat Rate





EPRI ELECTRIC POWER RESEARCH INSTITUTE

Presented By: Shawn Cochran, P.E.

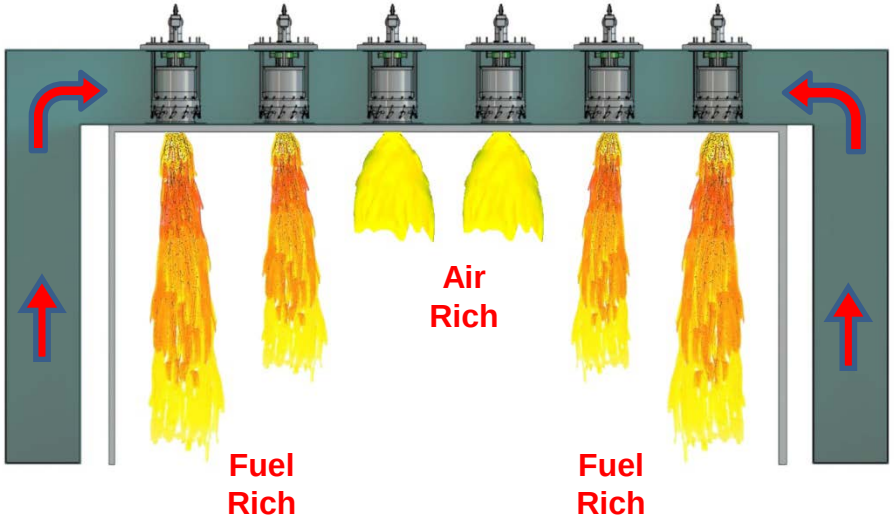
Pulverizers are the Heart of the Combustion System

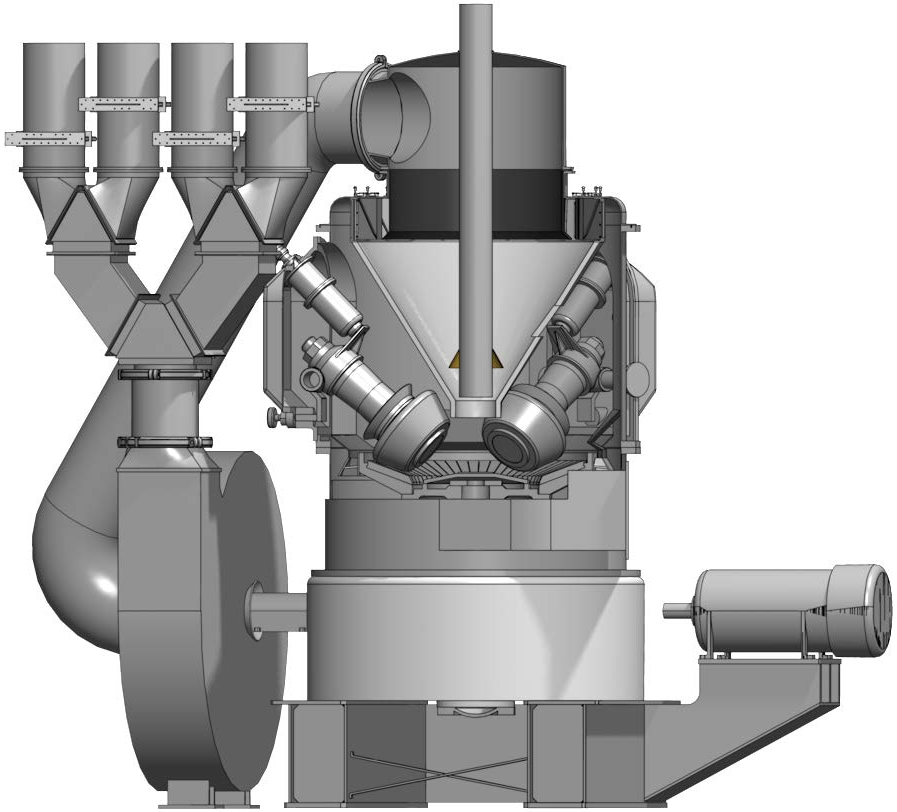
- Nine of the “13 Essentials” deal directly with the pulverizers!

1. Furnace exit must be oxidizing preferably, 3% with no single point below 2%
2. ***Fuel lines must be balanced to each burner by “Clean Air” test within ±2%***
3. ***Fuel lines balanced by “Dirty Air” test, using a Dirty Air Velocity Probe, within ±5%***
4. ***Fuel lines balanced in fuel flow within ±10%***
5. ***Fuel fineness shall be ≥75% passing a 200 mesh sieve and ≤0.1% retained on a 50 mesh sieve***
6. ***Primary airflow shall be accurately measured & controlled to within ±3%***
7. Overfire airflow shall be accurately measured & controlled to within ±3%
8. ***Primary air/fuel ratio shall be accurately controlled when above minimum***
9. ***Fuel line minimum velocities shall be 3,300 ft/min***
10. Mechanical tolerances of burners and dampers shall be ±1/4” of better
11. Secondary air distribution to the burners should be within ±10%
12. ***Fuel feed to the pulverizers should be smooth during load changes and controlled as accurately as possible. Load cell equipped gravimetric feeders are preferred.***
13. ***Fuel feed quality and size should be consistent. Consistent raw coal sizing to the pulverizers is a good start.***

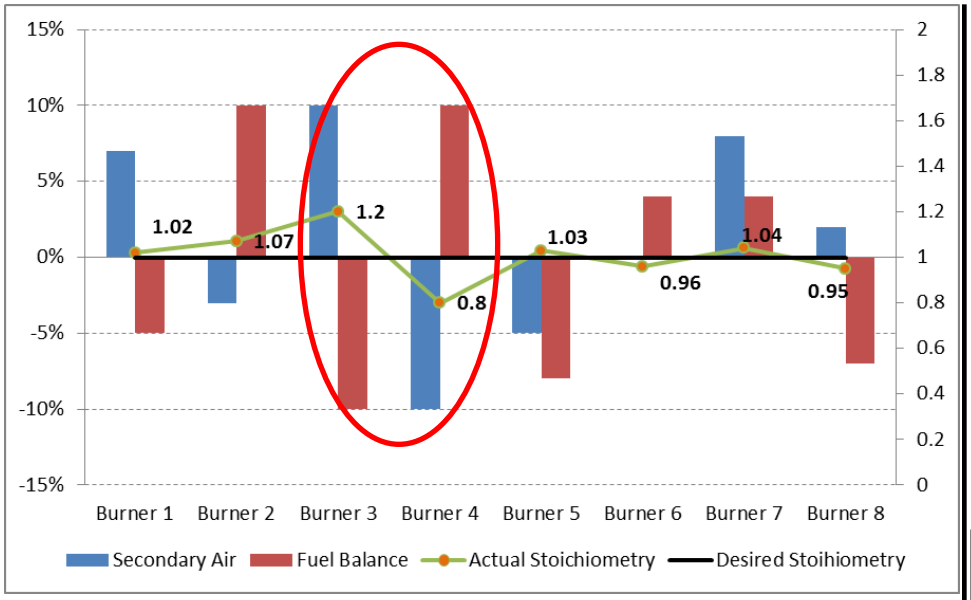
Achieving Acceptable Pulverizer Performance

- Fuel balance within ±10% is desirable and very difficult to achieve!
  - Multiple factors affect pulverizer performance
    - Clean air flow
    - Fuel fineness
    - Primary air/fuel ratios
    - Coal quality & consistency
    - Mechanical tolerances



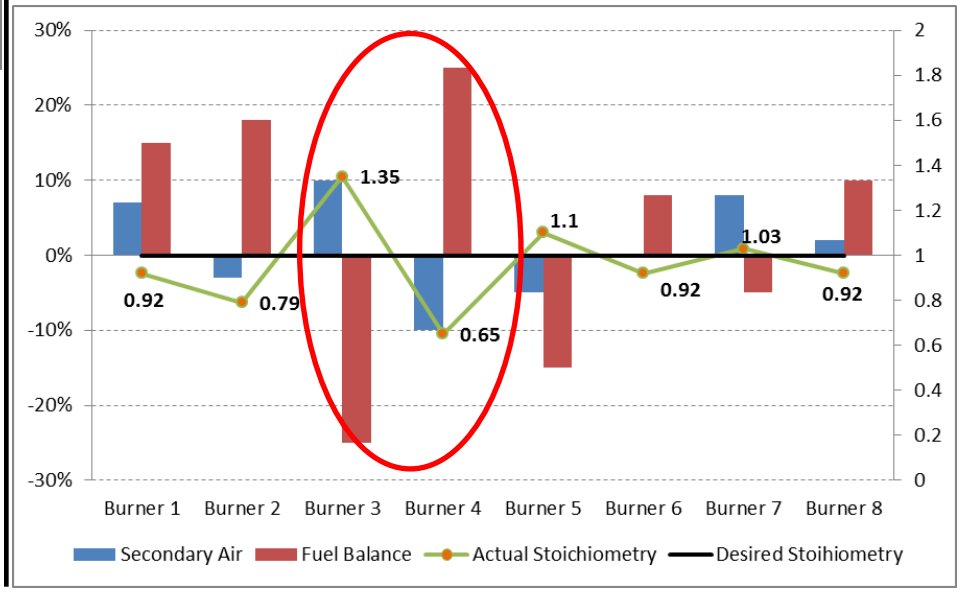


Affect of Fuel Balance on Burner Stoichiometry

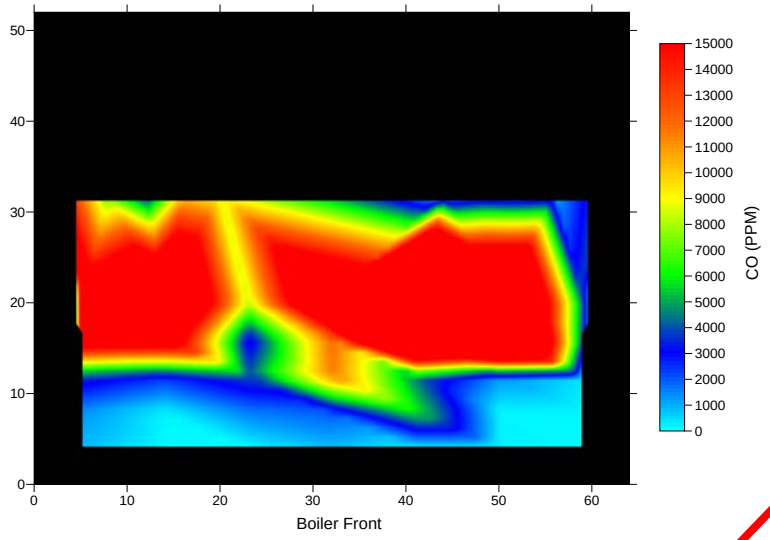


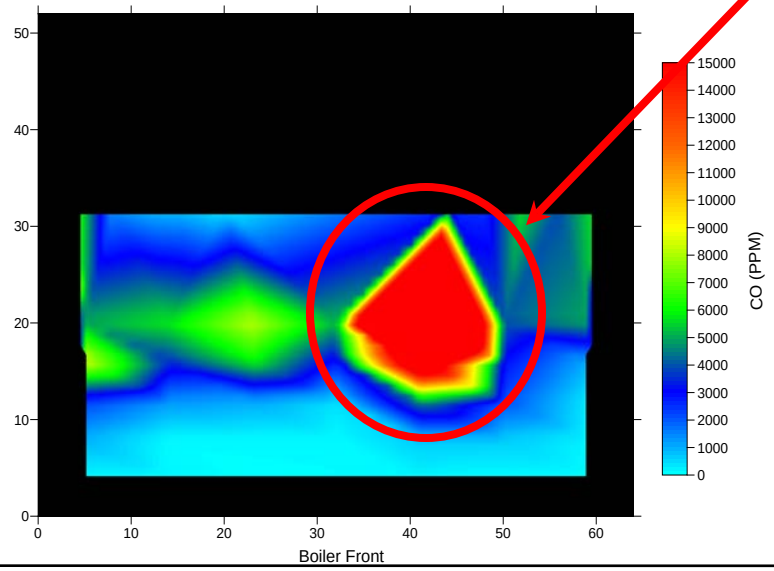
- Case #1
  - 15% Excess Air
  - 15% Overfire Air
  - +/- 10% Secondary Air Balance
  - +/- 10% Fuel Balance

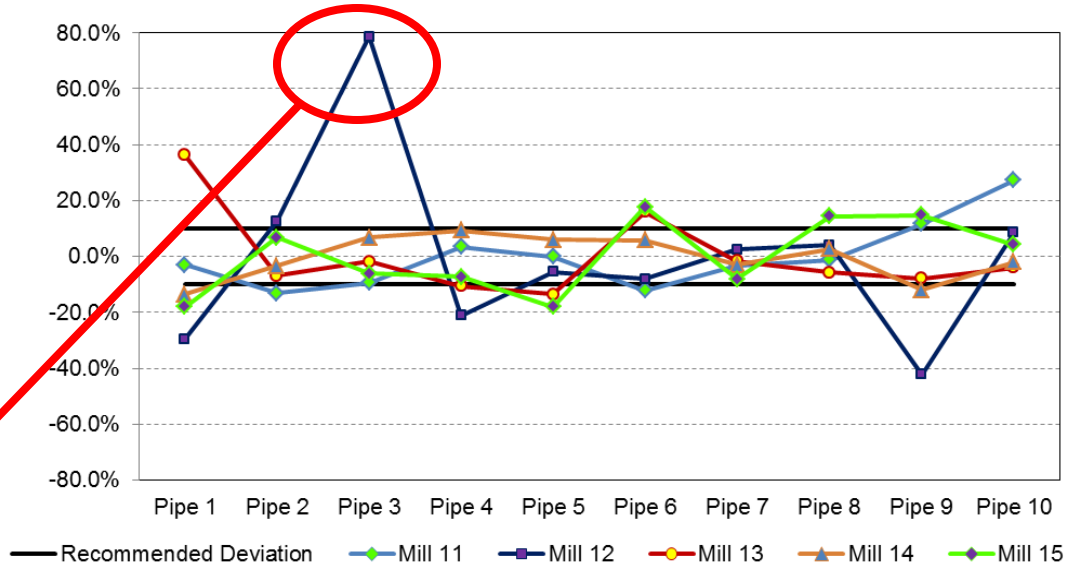
- Case #2
  - 15% Excess Air
  - 15% Overfire Air
  - +/- 10% Secondary Air Balance
  - +/- 25% Fuel Balance



Affect of Fuel Balance on Burner Stoichiometry



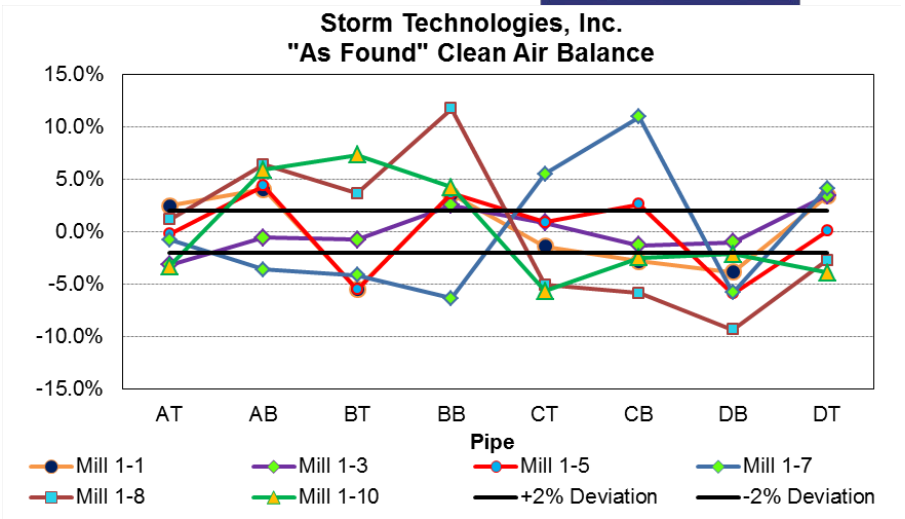


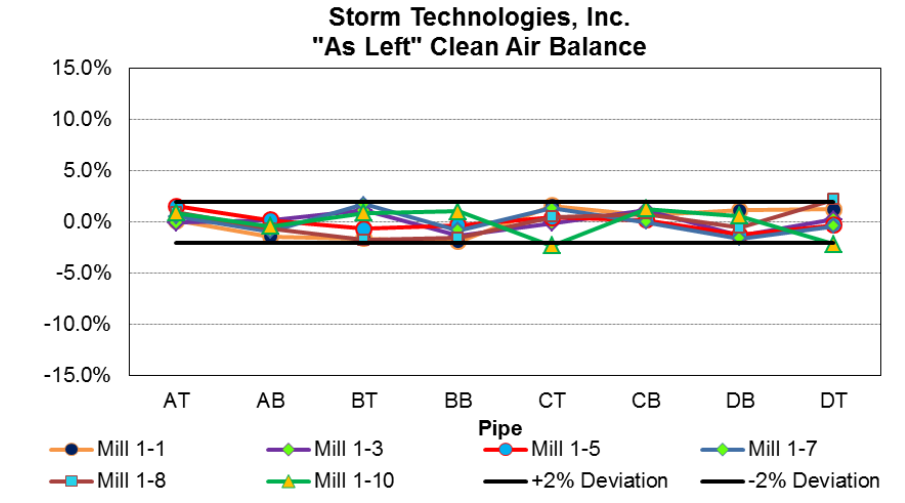


- Extremely high CO and low O_2 found directly above the burner with 80% high fuel flow.
- Burner adjustments would not correct

Balancing Primary Airflow

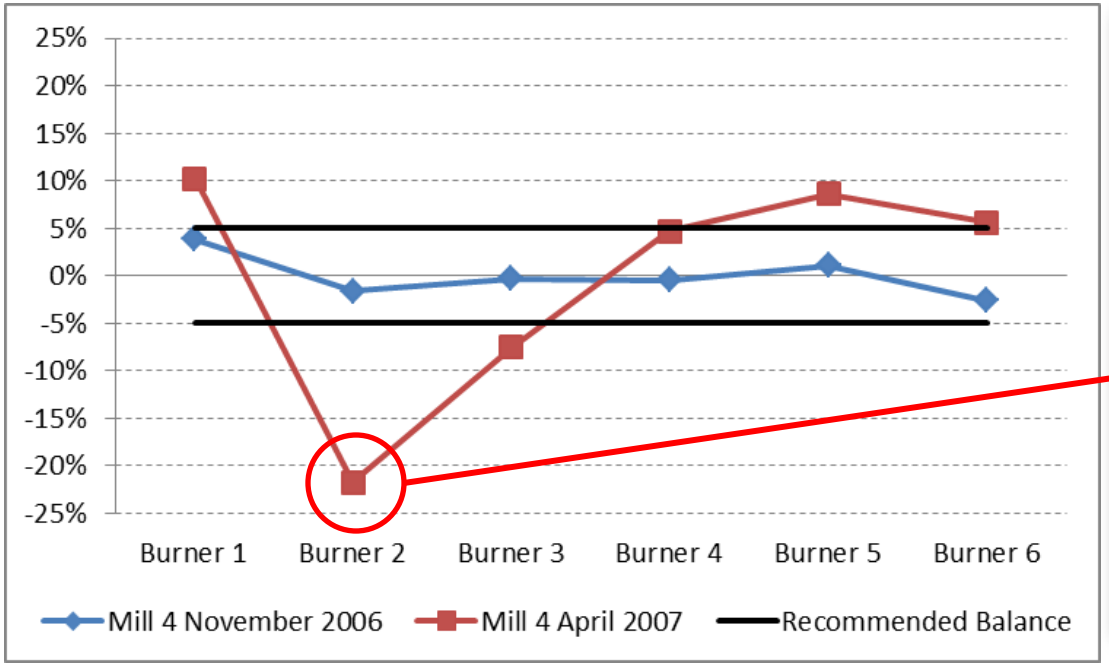
- Clean air balance to each of the burners is the first step to achieving good fuel distribution
- Dirty air balance typically follows the clean air balance

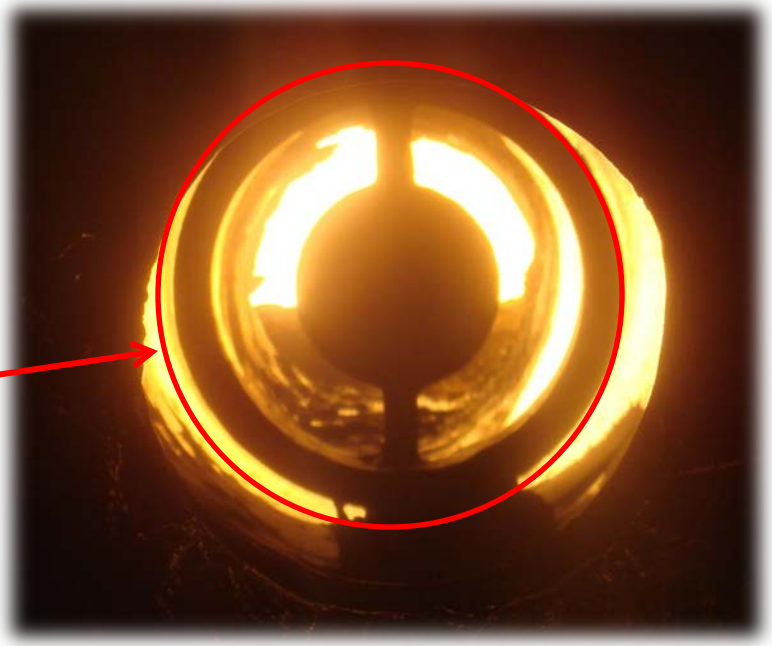




Balancing Primary Airflow

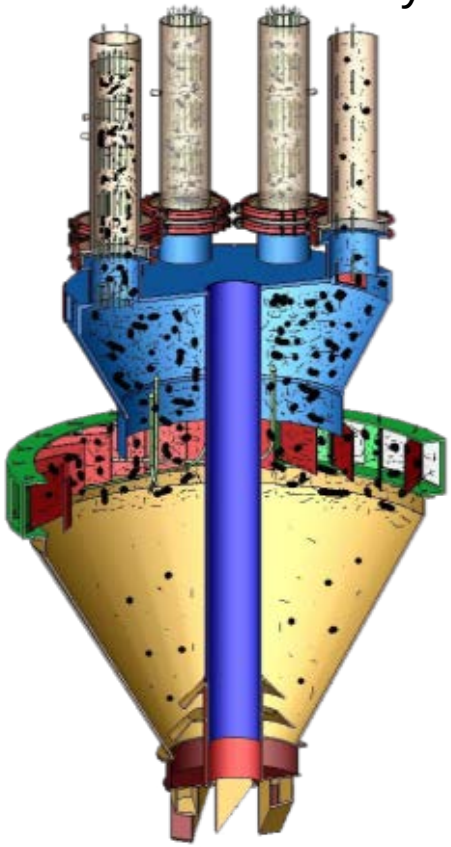
- Clean & dirty air balance should be checked on a regular balance and after any outage or pulverizer overhaul!

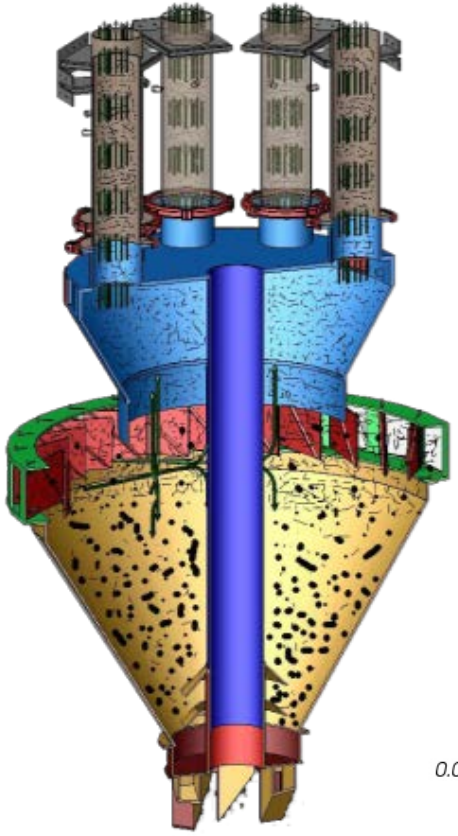


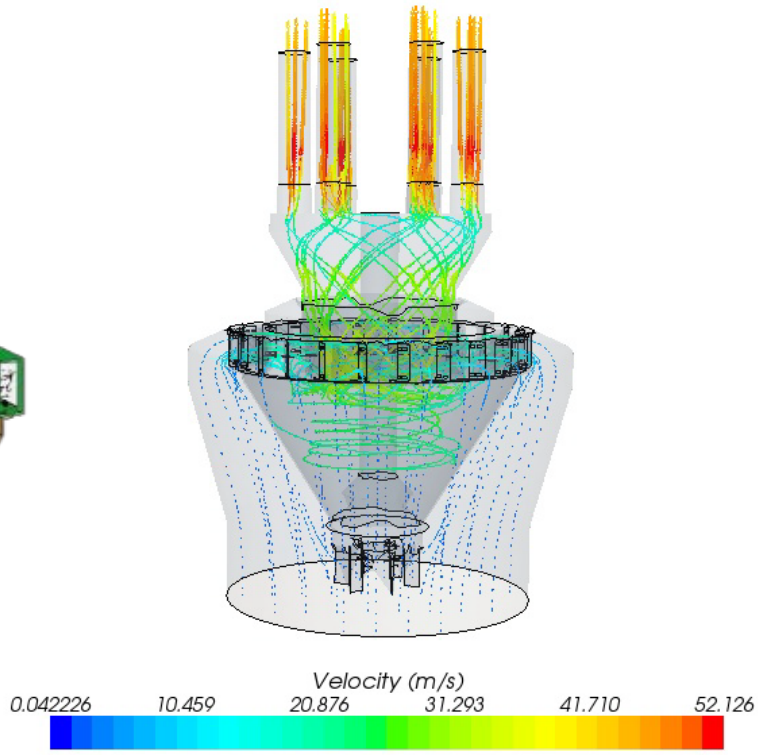


Fuel Fineness

- Fuel fineness directly affects fuel distribution and combustion efficiency!





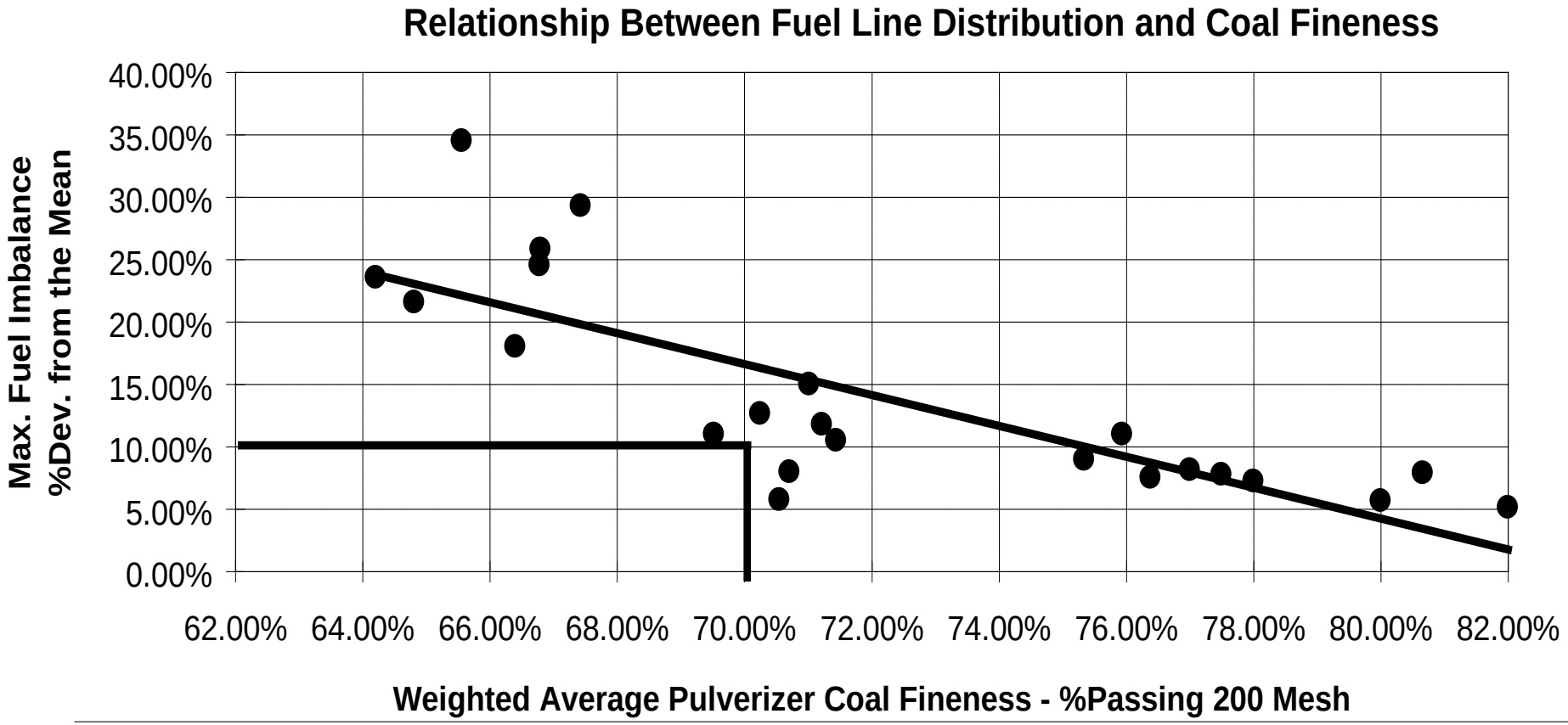


Poor Coal Fineness often yields poor distribution

Good Fineness Creates a homogenous & balanced mixture & will produce a more homogenous mixture if mechanical synchronization is optimum

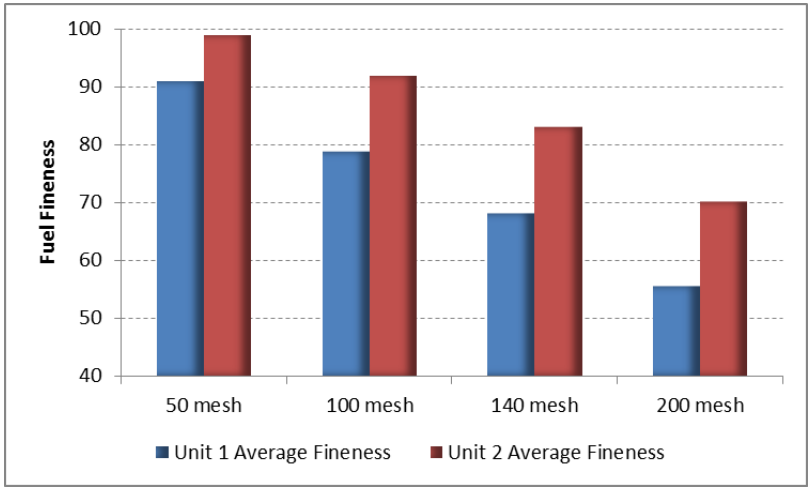
Fuel Fineness

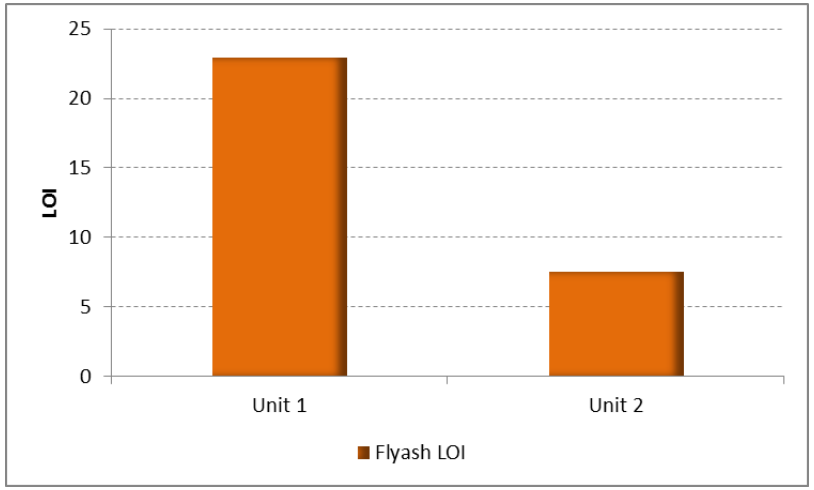
- Coal is roughly 1,000 times more dense than air. So improving fuel fineness helps to improve fuel distribution



Fuel Fineness

- As fuel fineness increases, fuel balance will improve and unburned carbon levels will decrease, if excess oxygen is available in the furnace.
  - The difference in flyash LOI between Unit 1 & 2 equates to roughly $1,500,000.00 in annual savings in fuel costs alone.
    - *Cost savings based off of and estimated $3.00/mmBtu, 80% capacity factor and a heat rate of 9,800 Btu/kWhr*

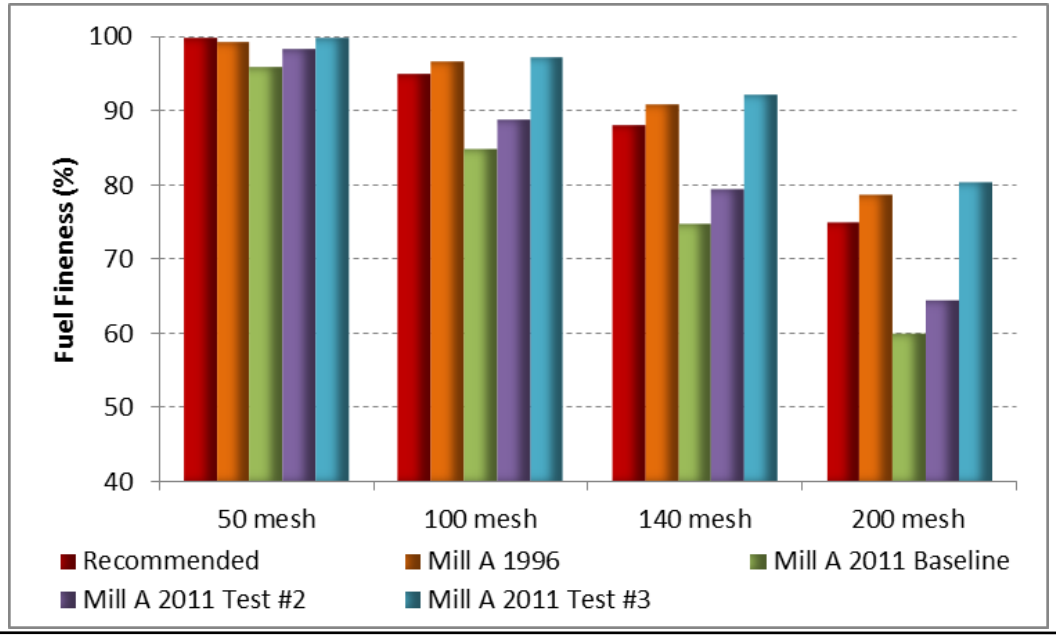




Fuel Fineness

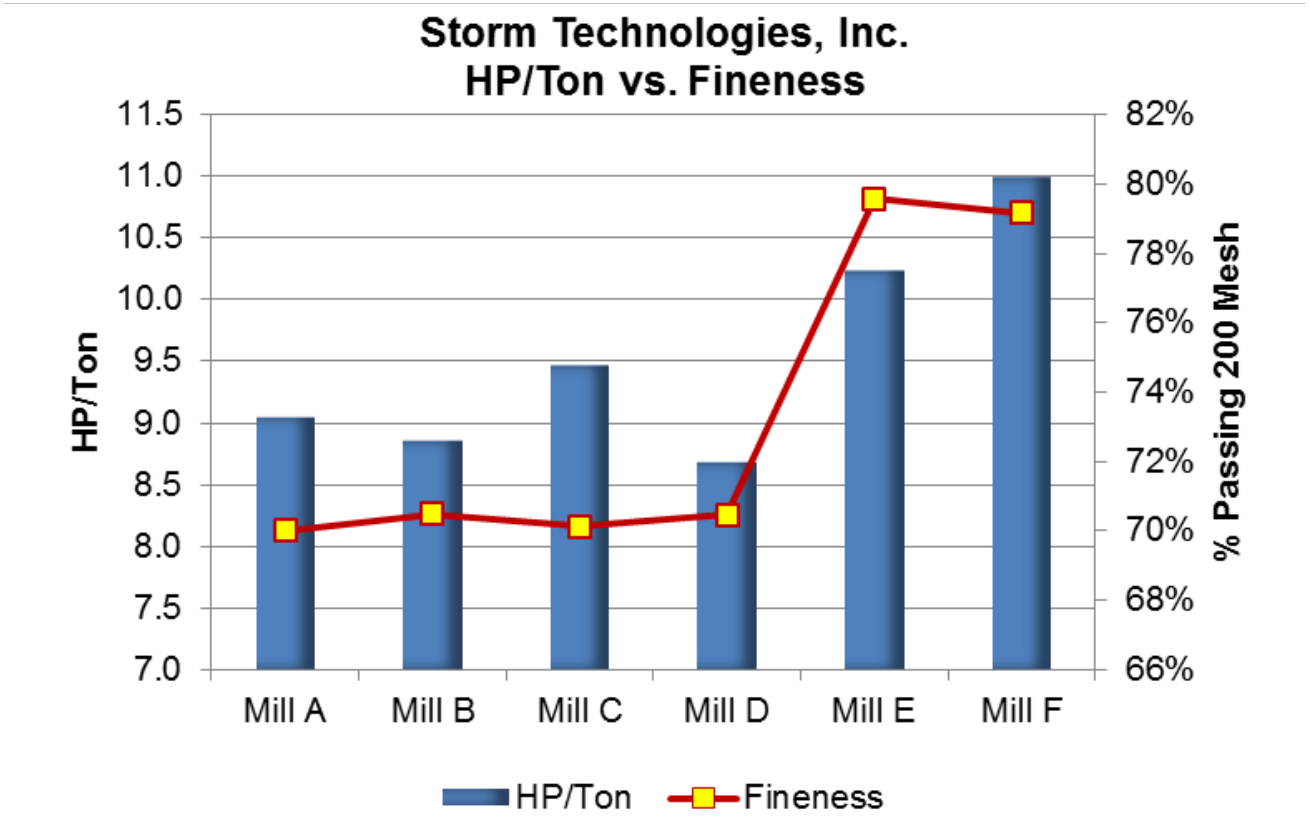
- Tested pulverizer performance often varies from day to day pulverizer performance.
- Dynamic classifiers make it easy for pulverizer performance to change to save on auxiliary power reductions, load changes, etc.
- Adverse effects on heat rate and reliability of reduced pulverizer performance are often not considered

  - Similar coals were being fired in ‘96 and ‘11. Adjustments were made to classifier speed while onsite in 2011 to improve performance without hindering pulverizer capacity.



Auxiliary Power vs. Fuel Fineness

- The pulverizers are NOT the place to save on auxiliary horsepower.
- More Pulverizer Power = Better Combustion



Primary Airflow Measurement & Control

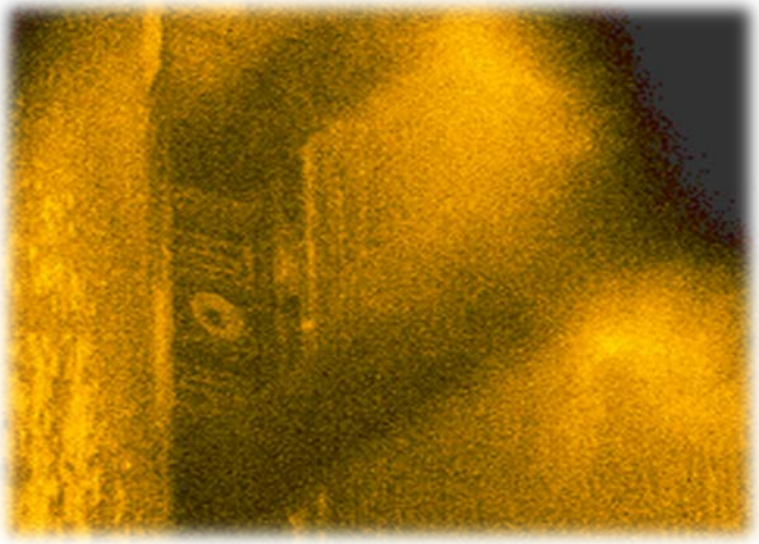
- The main purpose of primary air is to dry and transport the fuel to the furnace for combustion

Affects of High Primary Air

- Poor fuel fineness
- Poor fuel distribution
- Increased wear rates on the pulverizer, fuel lines and burner components
- Poor mixing at the burner front
- Increased secondary combustion, FEGT's, slagging/fouling
- Increased spray flows
- Increased emissions (i.e. CO & NO_X)
- Decreased APH performance
- Decreased heat rate

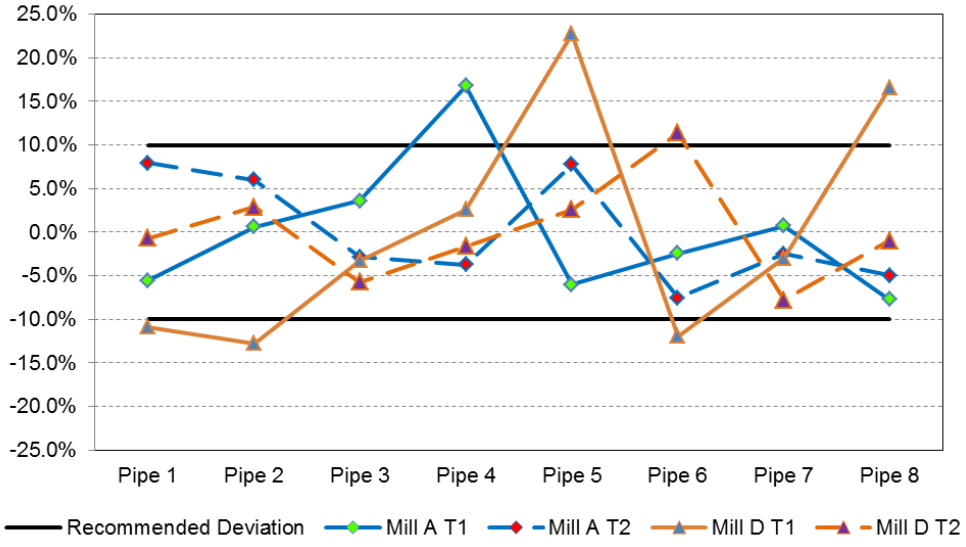
Affects of Low Primary Air

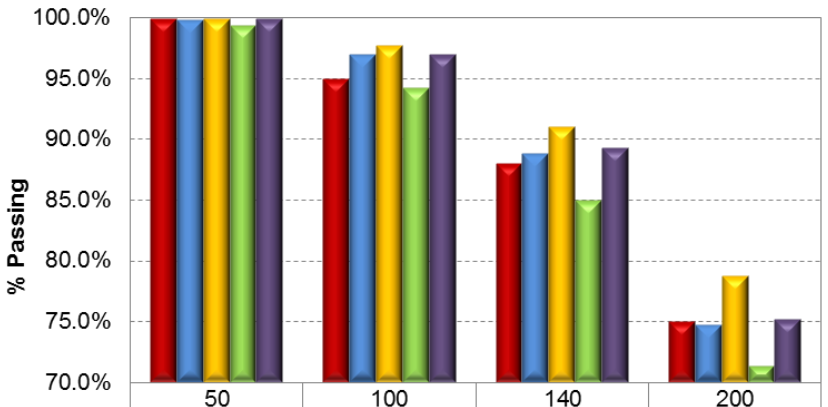
- Possible fuel layout
- Increased coal rejects
- Increased probability of fires due to layout and raw coal rejects
- Less moisture evaporation from the coal (if hot air is not available)



Primary Airflow Measurement & Control

- A decrease of primary air flow from 1.8 to a 1.5 air/fuel ratio significantly improved fineness
- Less tempering airflow was utilized which by itself results in improved unit heat rate
- Improved fuel balance and fineness will also yield heat rate improvements

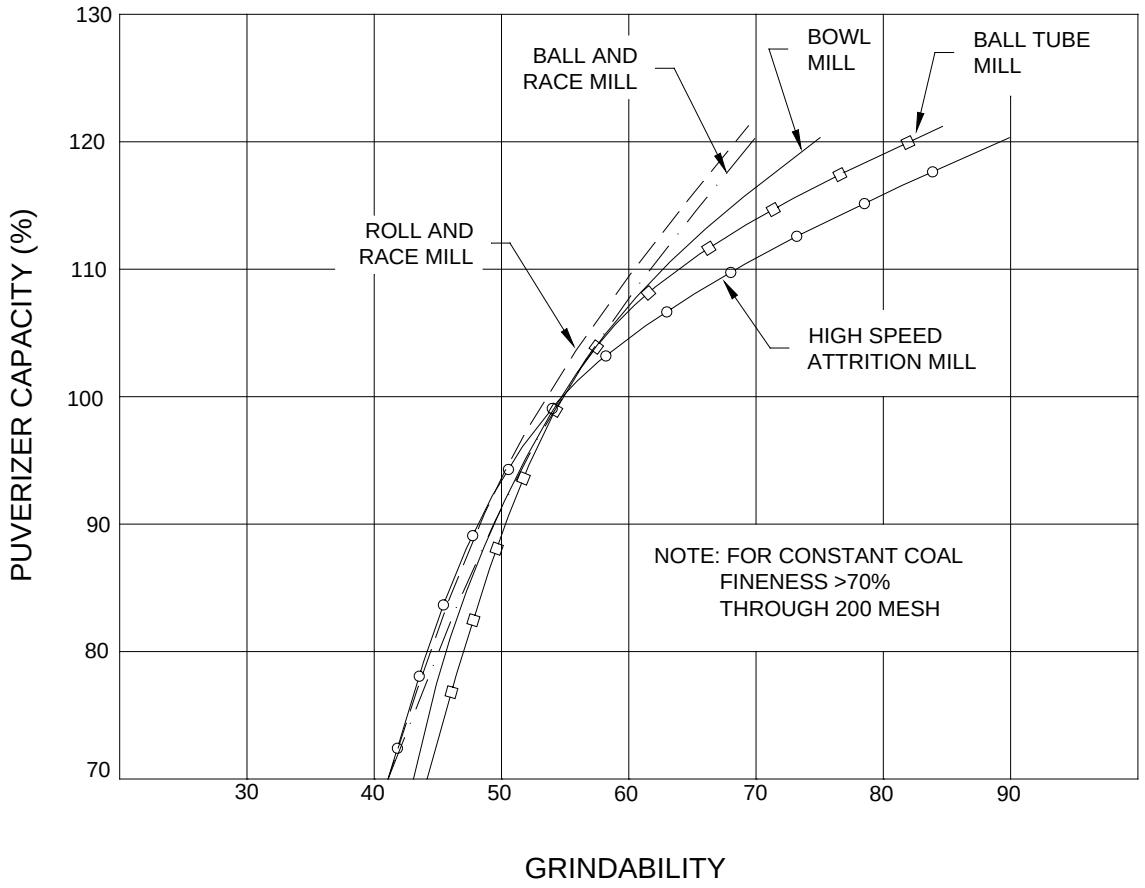




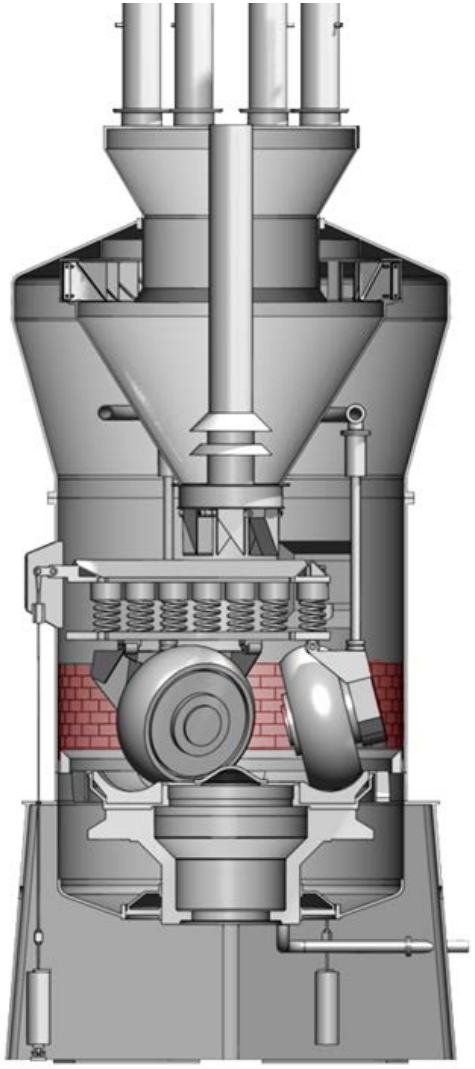
	50	100	140	200
Recommended	99.9%	95.0%	88.0%	75.0%
Mill A T1	99.8%	97.0%	88.8%	74.7%
Mill A T2	99.9%	97.7%	91.0%	78.7%
Mill D T1	99.3%	94.3%	85.0%	71.4%
Mill D T2	99.9%	97.0%	89.3%	75.2%

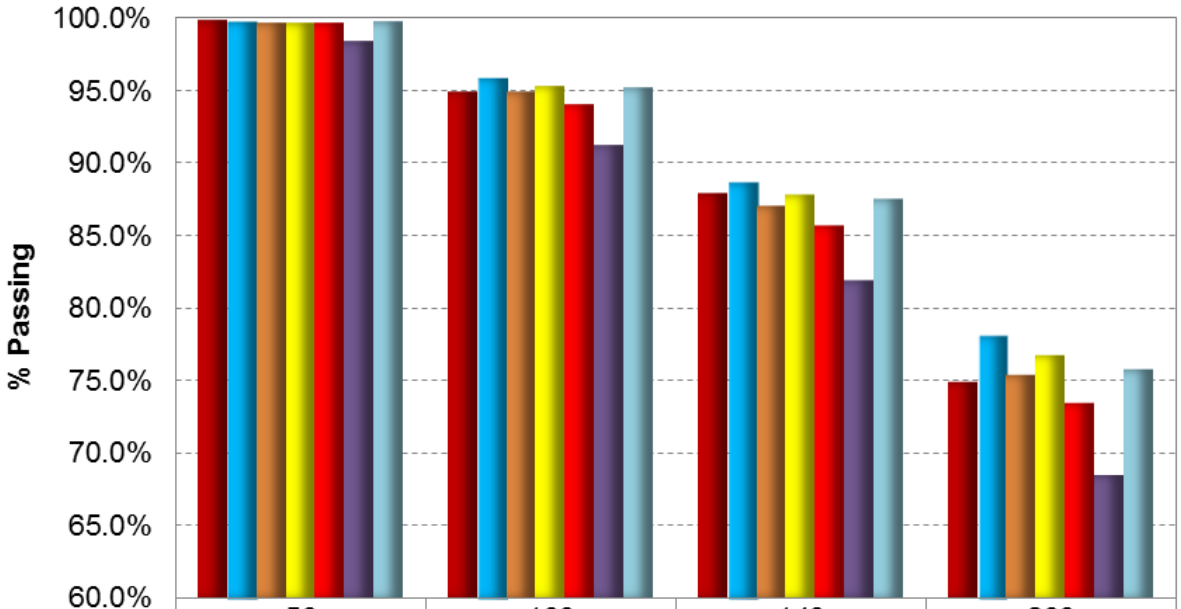
Coal Quality

- Factors affecting performance
  - Raw coal sizing
  - Hardgrove index
  - Moisture
  - Volatile matter
  - Ash mineral analysis



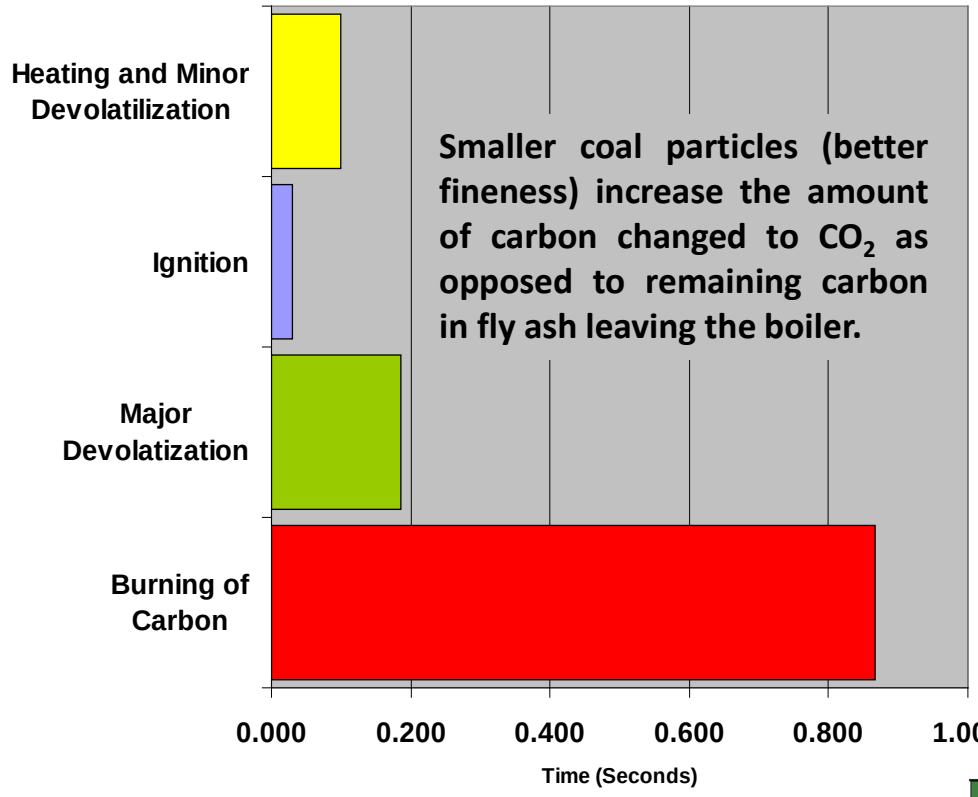
Mechanical Tolerances Must Be Blueprinted

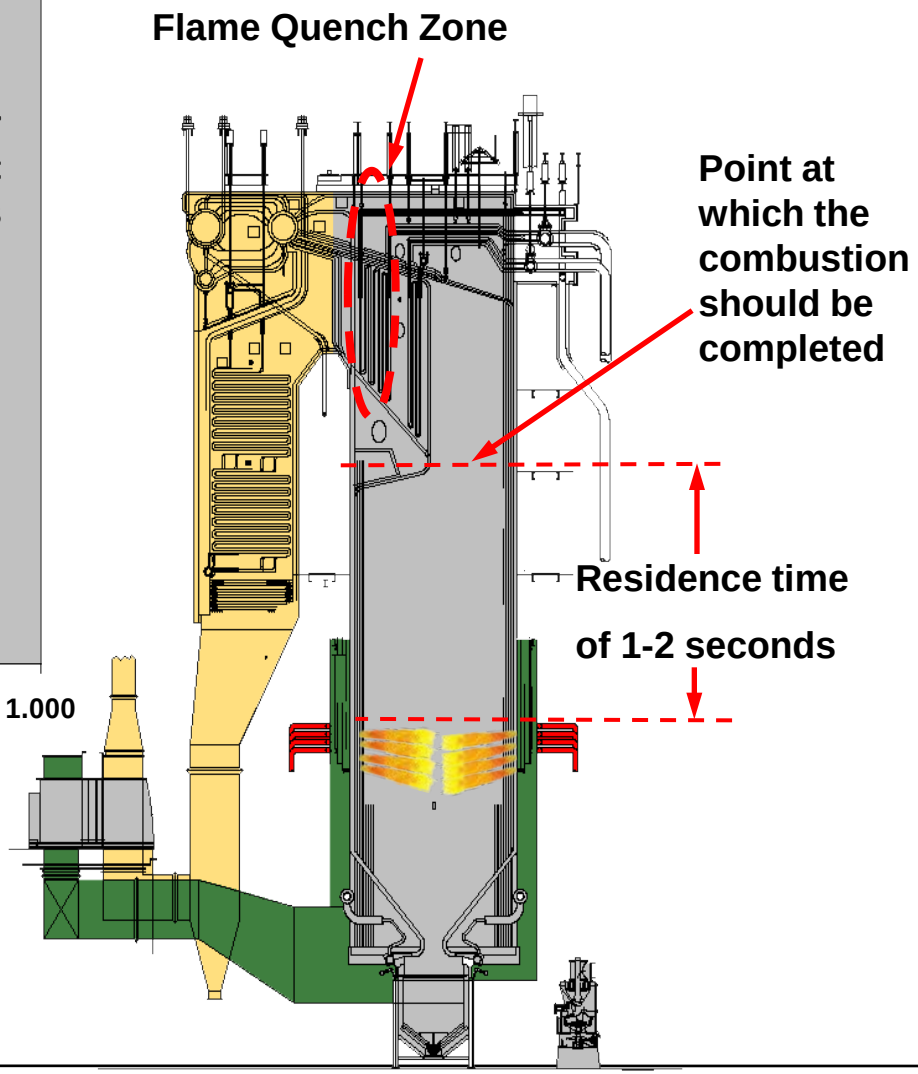




	50	100	140	200
Recommended	99.9%	95.0%	88.0%	75.0%
Apr-08	100%	96%	89%	78%
Jan-12	100%	95%	87%	75%
Apr-13	100%	95%	88%	77%
Nov-13	100%	94%	86%	74%
Apr-14	98%	91%	82%	69%
May-14	100%	95%	88%	76%

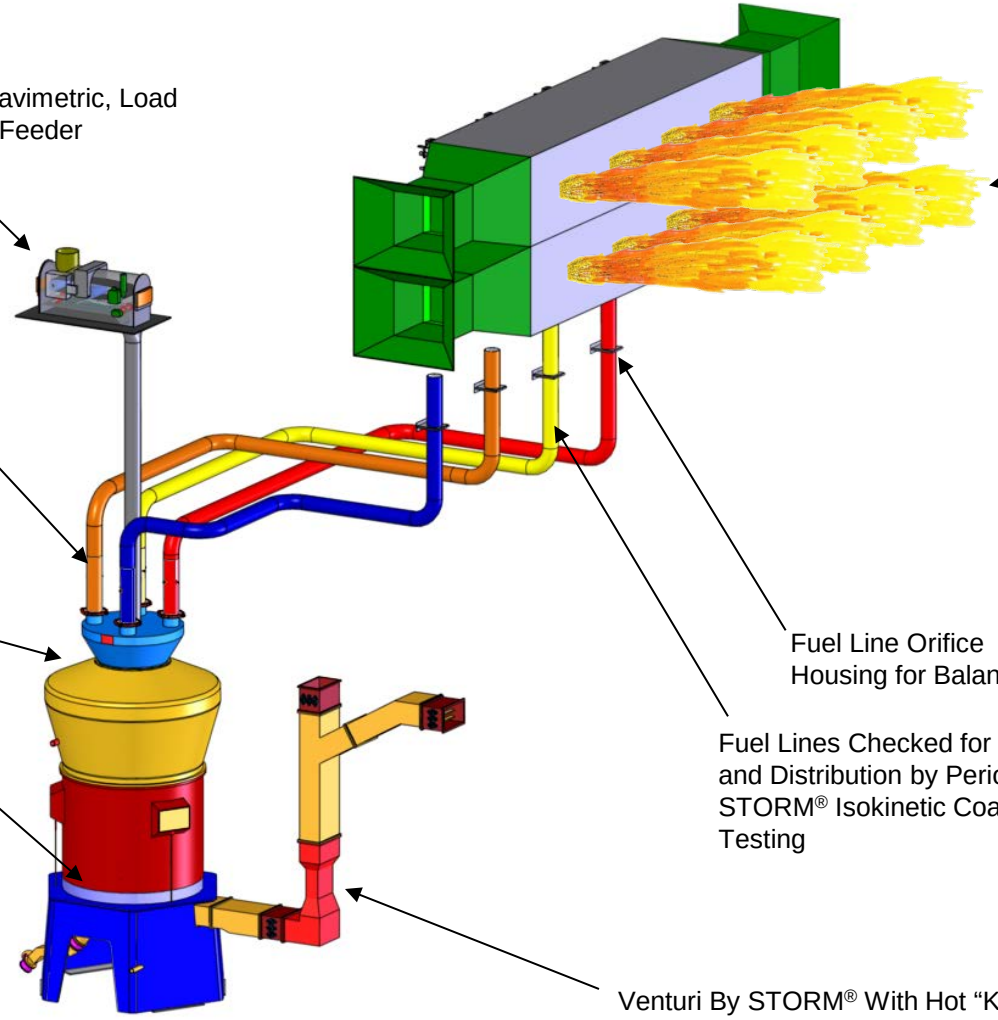
Firing System Changes and the Possible Effect on Efficiency





This graph illustrates typical time requirements for combustion of coal. These times will vary with different coals & firing conditions but the combustion of carbon always requires the most time

Pulverizers Effect on Heat Rate & Efficiency



Microprocessor, Gravimetric, Load Cell STOCK® Coal Feeder

Desirable Air/Fuel Ratio1.8 #Air / #Fuel

MPS-89 Pulverizers Mechanically Tuned to STORM® Specifications

Throat Velocity: STORM® Design Parameters

Fuel Line Orifice Housing for Balancing

Fuel Lines Checked for Fineness and Distribution by Periodic STORM® Isokinetic Coal Sampler Testing

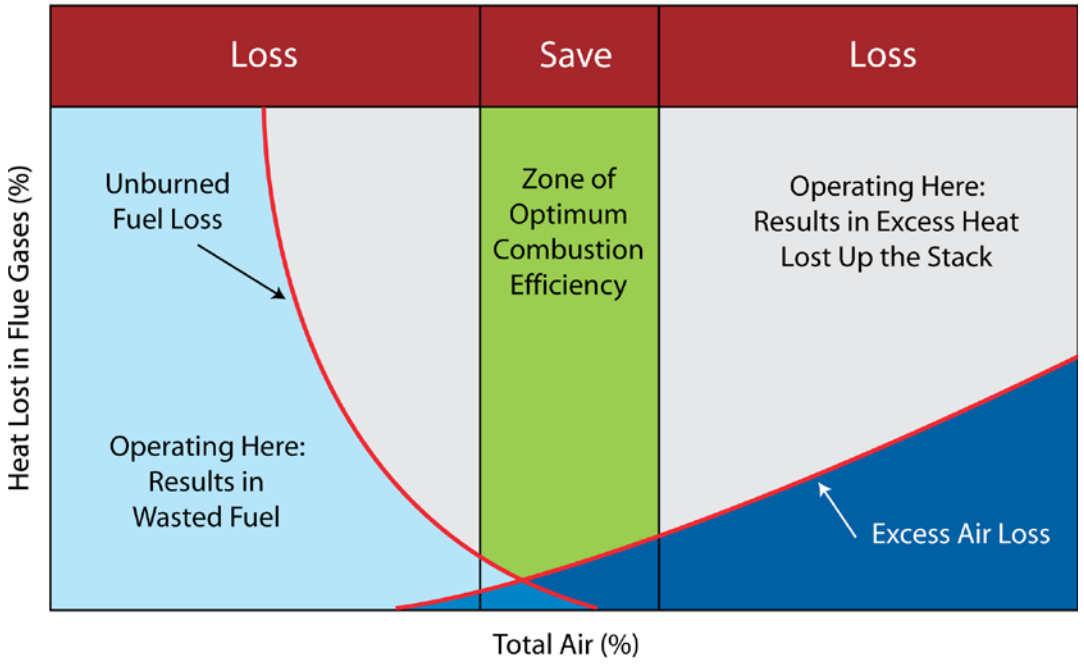
Venturi By STORM® With Hot "K" Calibration

Excellence in Pulverizer Performance and Fuel Line Balancing Results in Uniform Flames Here For the Advantages of:

- Less Slagging
- Less Fouling
- Better Flyash LOI
- Reduced Dry Gas Loss
- Fuel Flexibility
- Reduced "POP CORN" Ash To SCR
- Reduced "FEGT"
- Less De-Superheating Water Flows
- Reduced Sootblowing

In Conclusion

- Neglecting the pulverizers can result in heat rate increases as a result of:
  - Imbalances in fuel
  - Poor fuel fineness levels
  - Elevated primary air flow levels
  - Mechanical tolerances becoming out of spec
- Routine testing on a quarterly or monthly basis is recommended to help track performance and circumvent major problems



Thank You

Shawn Cochran, P.E.

Storm Technologies, Inc.

Albemarle, NC

www.stormeng.com

704-983-2040