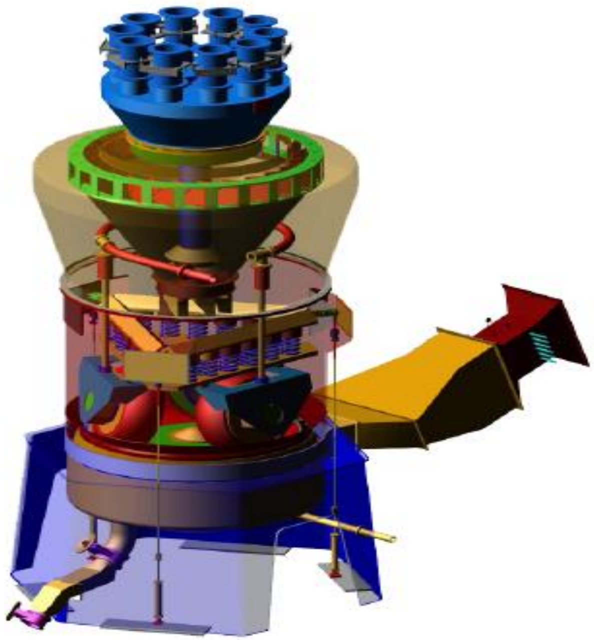
Performance Driven Maintenance of Coal Pulverizers

Importance of Mill Performance Testing



Data and Case Studies
Prepared by:

Jesse Parnell
Danny Storm
Adam McClellan

Presented by;
Dick Storm

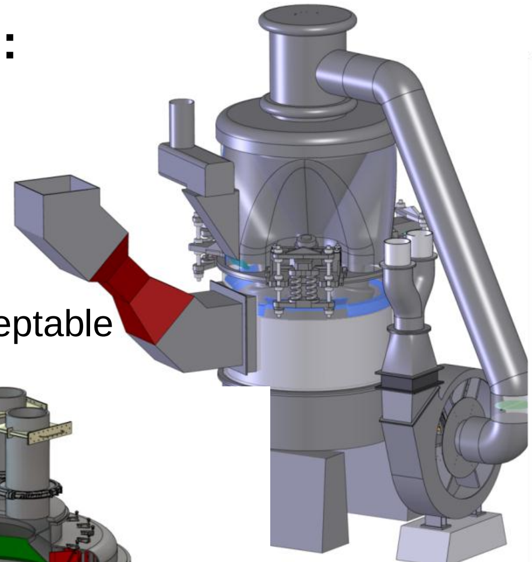
All of Storm Technologies, Inc.

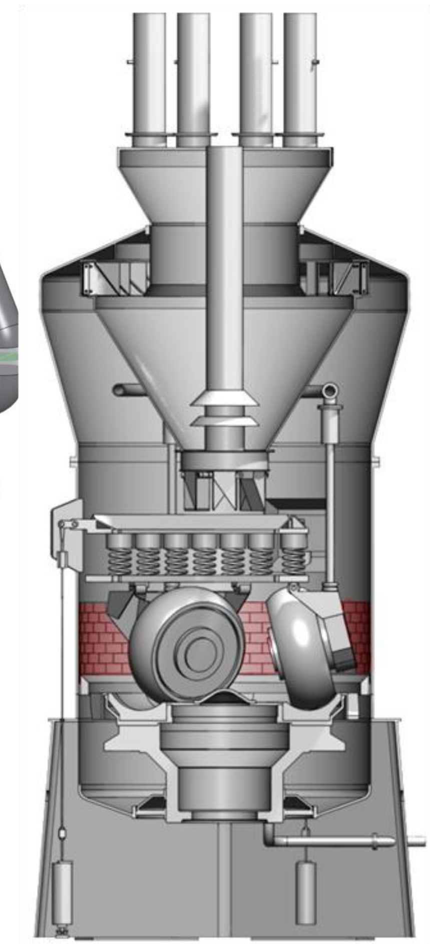
ELECTRIC POWER RESEARCH INSTITUTE

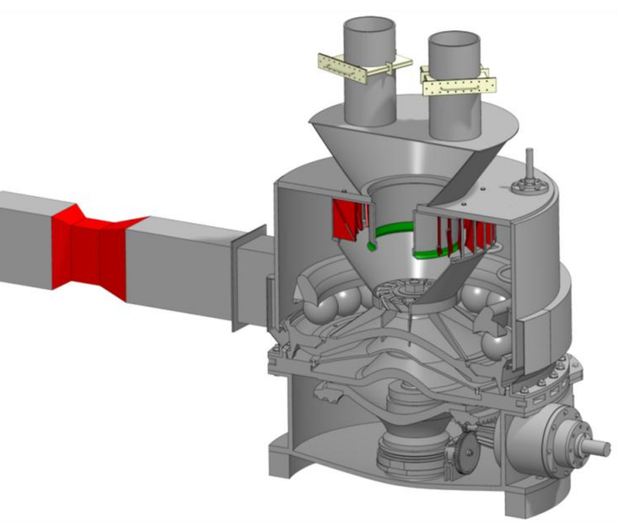
Overhauling a Pulverizer for Best Performance

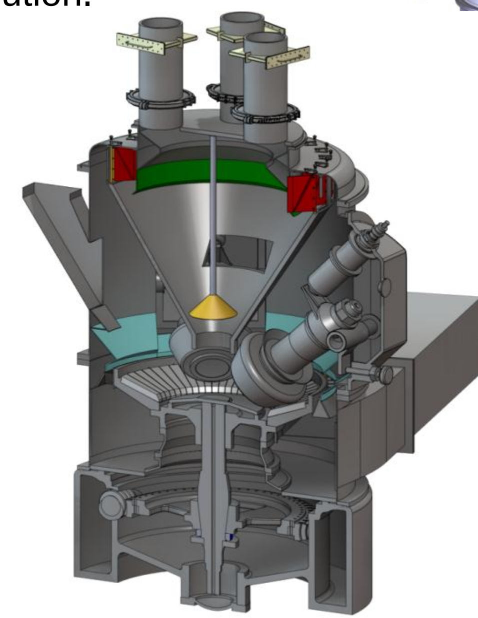
Typical Triggers for a Pulverizer Overhaul:

- Prescribed maintenance interval (hours, tons throughput, months…
- Noise, Coal Rejects excessive, Capacity Short…
- Repair damaged or worn parts, grinding elements classifier components, etc.
- Prove by Testing, “Best” Pulverizer Performance is acceptable Coal Fineness and Coal Distribution.



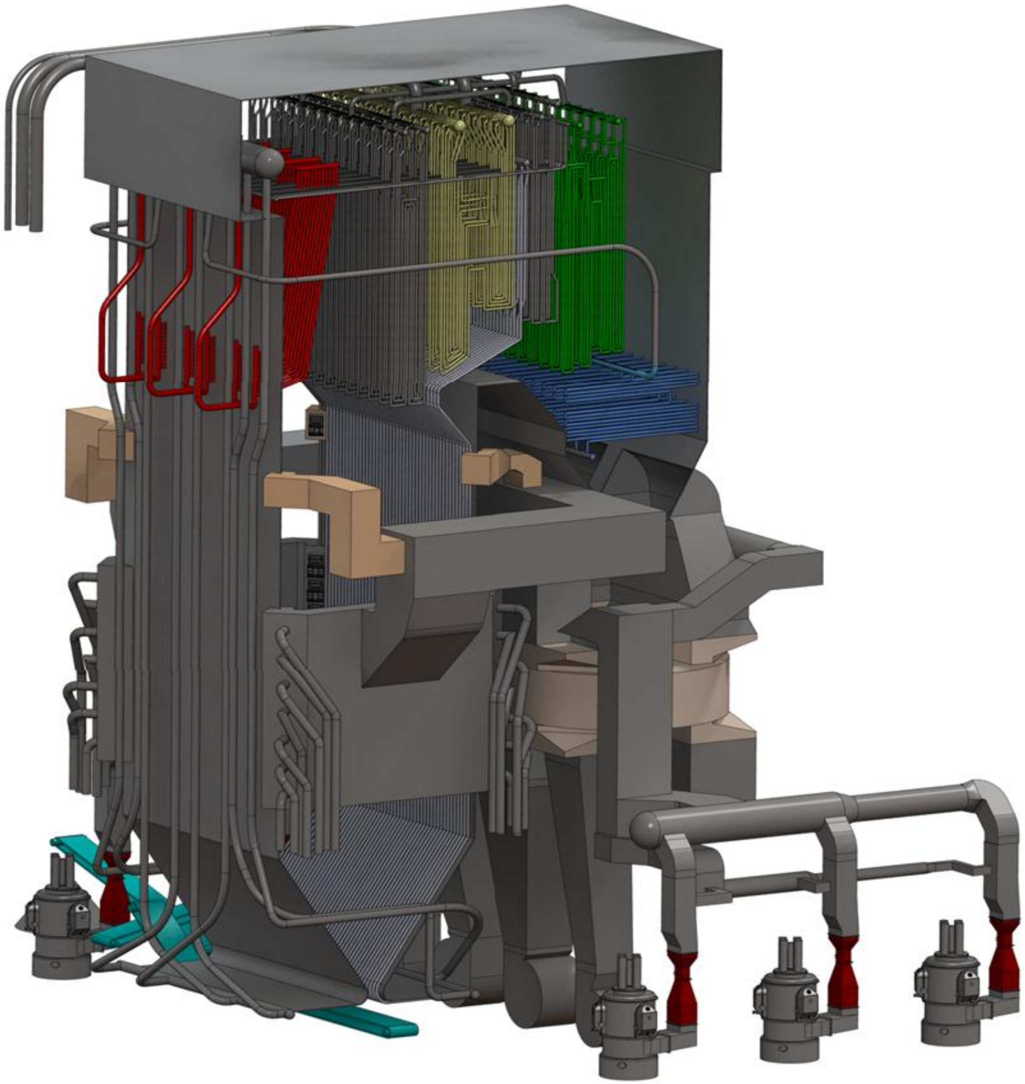






Fineness and Distribution Needs to be Measured to be Managed

Mediocre Combustion is not an"Option"



Coal Pulverizers are the Heart of a Pulverized Coal Fueled Boiler!
Optimization is not "Optional" today!
Why?

- Ever Changing Regulations….
- Fuel Flexibility for Competitive Power Generation with Natural Gas
- Slagging
- Fouling of SCR and Air Heaters
- Boiler Reliability (minimize tube failures from overheating or fireside corrosion)
- CO Emissions
- Flyash carbon losses
- High Reheat Sprays
- Minimize Sootblowing steam losses and tube erosion
- Heat-Rate

13 Essentials for Optimum Combustion

9 of the 13 Essentials are Pulverizer and Fuel Line Related

STORM®

Specialists in Combustion and Power

Thirteen Essentials of Optimum Combustion for Low NO_x Burners

1. Furnace exit must be oxidizing preferably, 3%.
2. Fuel lines balanced to each burner by "Clean Air" test ±2% or better.
3. Fuel lines balanced by "Dirty Air" test, using a Dirty Air Velocity Probe, to ±5% or better.
4. Fuel lines balanced in fuel flow to ±10% or better.
5. Fuel line fineness shall be 75% or more passing a 200 mesh screen. 50 mesh particles shall be less than 0.1%.
6. Primary airflow shall be accurately measured & controlled to ±3% accuracy.
7. Overfire air shall be accurately measured & controlled to ±3% accuracy.
8. Primary air/fuel ratio shall be accurately controlled when above minimum.
9. Fuel line minimum velocities shall be 3,300 fpm.
10. Mechanical tolerances of burners and dampers shall be ±1/4" or better.
11. Secondary air distribution to burners should be within ±5% to ±10%.
12. Fuel feed to the pulverizers should be smooth during load changes and measured 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 of feed to pulverizers is a good start.

Common, Correctable Causes of “Poor” Combustion

- High Primary Airflow
- Obstructed Path for Coarse Particle Returns from Classifier
- Non – Optimum Mechanical Adjustments
- Poor Fuel Balance
- Non-Optimum Contour Grinding Elements

Our Point: If Coal Fineness is not representatively sampled, then Pulverizer Grinding Performance is not known?

Fineness Testing should be used as a trigger for maintenance on mills.

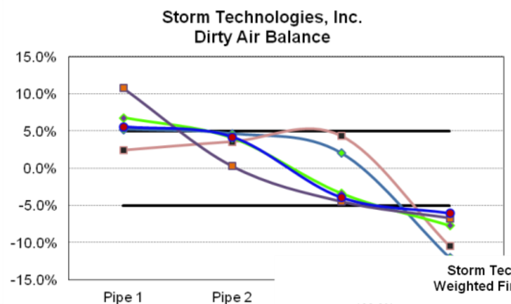
Maintenance Should be Performance Driven, not hours or tons

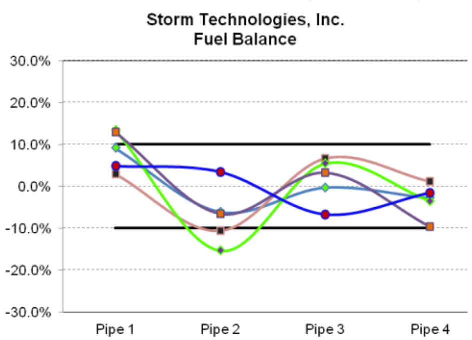
When?

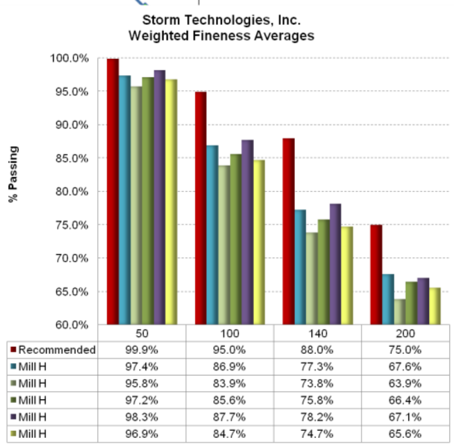
•Testing should be completed periodically and also after an overhaul.

Why?

•Just because a pulverizer is overhauled, does not mean that the fineness is up to required standards.





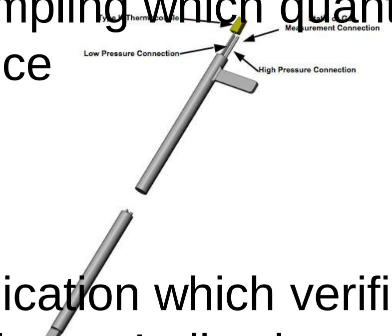


	50	100	140	200
Recommended	99.9%	95.0%	88.0%	75.0%
Mill H	97.4%	86.9%	77.3%	67.6%
Mill H	95.8%	83.9%	73.8%	63.9%
Mill H	97.2%	85.6%	75.8%	66.4%
Mill H	98.3%	87.7%	78.2%	67.1%
Mill H	96.9%	84.7%	74.7%	65.6%

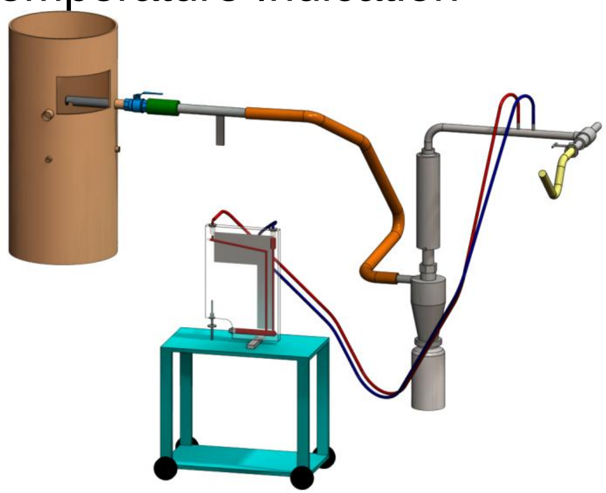
What should be tested and verified?

•Iso-kinetic Coal Sampling which quantifies

- Dirty Air Balance
- Fuel Balance
- Fuel Fineness
- Fuel Flow



- Primary Airflow Indication which verifies
  - Measured Airflow to Indication
  - Temperature Indication



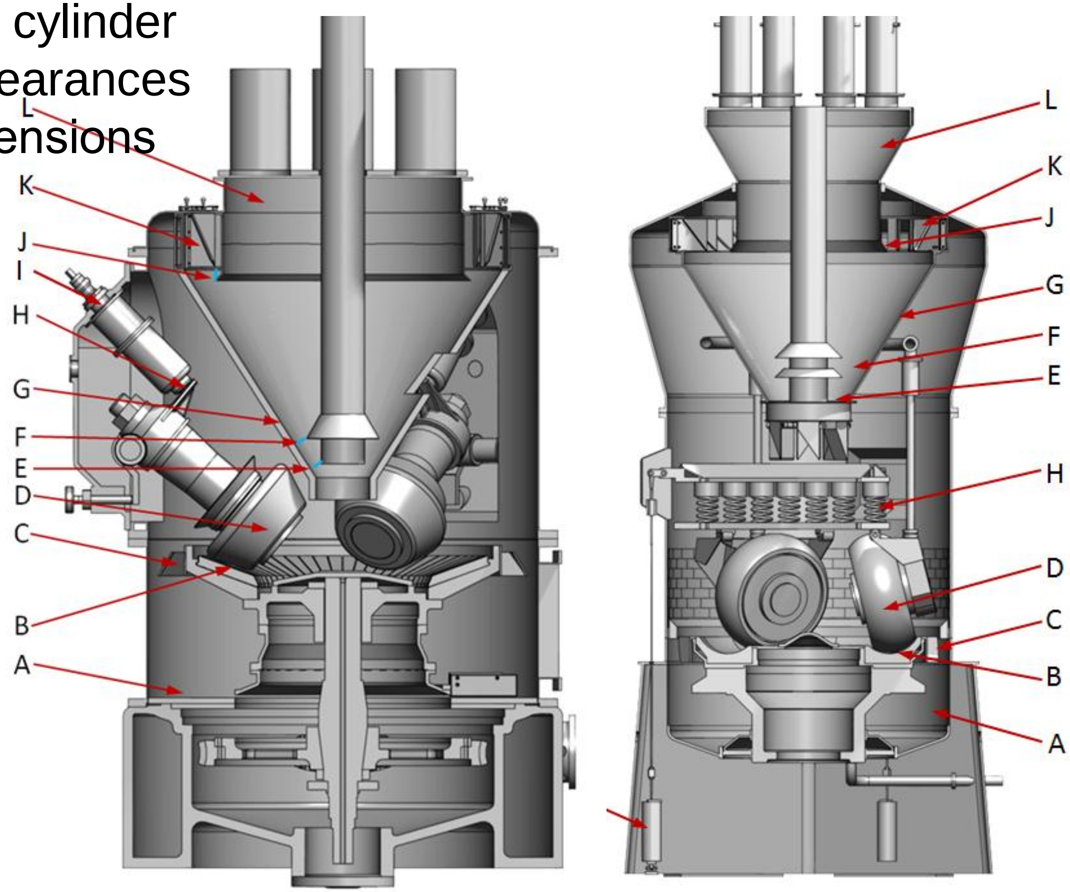
Typical Overhaul and Maintenance

Overhaul May Include:

- Replaced grinding elements
- Replaced/repaired worn area of classifier cones, blades and/or outlet cylinder
- Checked spring tensions, button clearances
- "Blueprint" the clearances and dimensions

Inspection points can be adapted to any type vertical spindle mill

A. Pyrite Sweep Conditions/Clearances
B. Grinding Element Condition/Clearances
C. Throat Dimensions/Opening
D. Roll/Journal Condition
E. Feed Pipe Clearances
F. Inverted Cone/Conical Baffle Clearances
G. Classifier Cone Condition
H. Button Clearance/Spring Height
I. Preload of Spring Canisters or Hydraulic Pressure
J. Outlet Cylinder Height in relation to Classifier Blades
K. Classifier Blade Condition / Length / Stroke / Synchronized Angles
L. Outlet Smooth, free of any obstructions or spin arresting protrusions into the spinning two phase mixture of coal and air



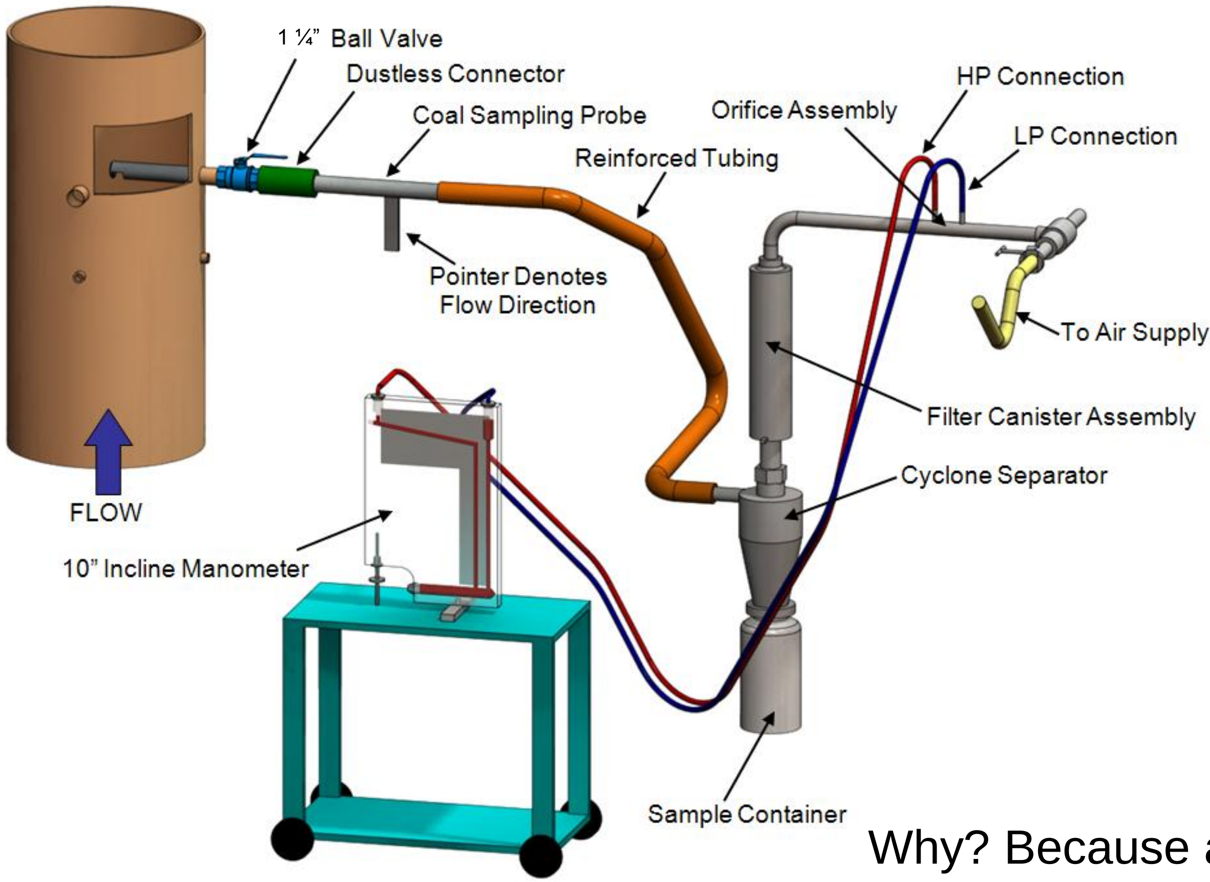
Coal Air Mixture Velocity Determination

Velocity pressure and setting the sample extraction rate is the 1st step that is needed to perform isokinetic coal sampling.

Once the velocity is ascertained, then isokinetic coal sampling is begun.

We call this, measuring the "Dirty Air Velocity"

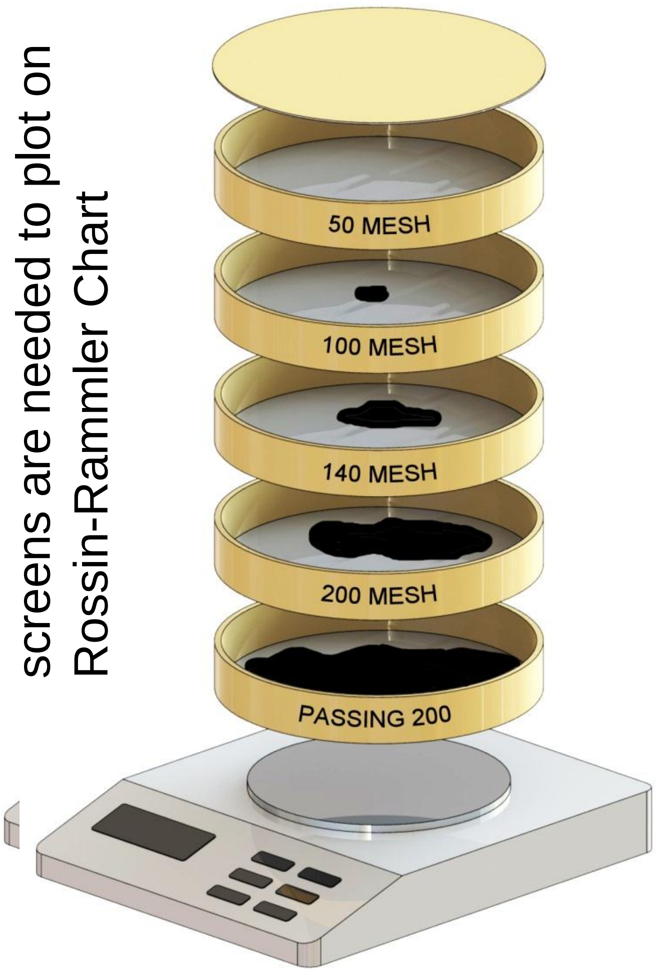
The Storm Isokinetic Coal Sampler



Why? Because accurate and representative Coal samples are needed for guidance on Next steps to mechanically tune the mill.

Plotting Coal Fineness Results & Particle Sizing

Key point!
With zero on 50 Mesh, then 3 more screens are needed to plot on Rossin-Rammler Chart



Fuel Fineness testing is a measure of performance

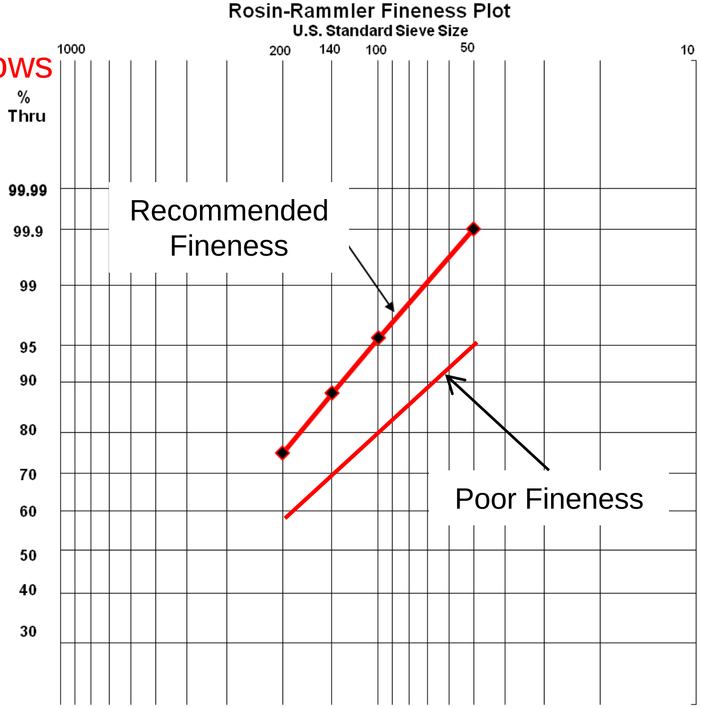
Good Performance Indication:

- Adequate throughput
- Minimal coal spillage
- No rumbling
- Recommended fineness
    - <0.1% retained on 50 mesh
    - >75% passing 200 mesh
- Bright and attached burner flames
- Low LOI (Direct impact of pulverizer performance)
- Balanced airflow in fuel lines
- **Balanced fuel flow to burners**

Possible issues from poor fineness

- Poor combustion
- Increased Carbon in Ash (LOI)
- Slagging and Fouling
- Secondary Combustion
- High CO leaving furnace
- Particulate loading on emission equipment
- Increased FEGT
- Increased spray flows

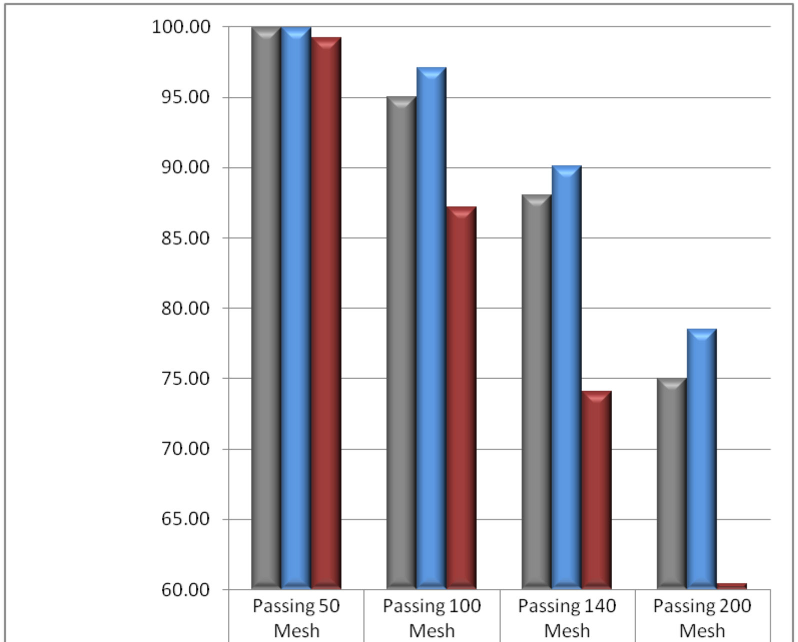
+50 Mesh



Testing = Knowing Performance

MPS 89 Following Outage, Fineness Deteriorated

Following a typical outage testing should be completed to verify performance is to par.

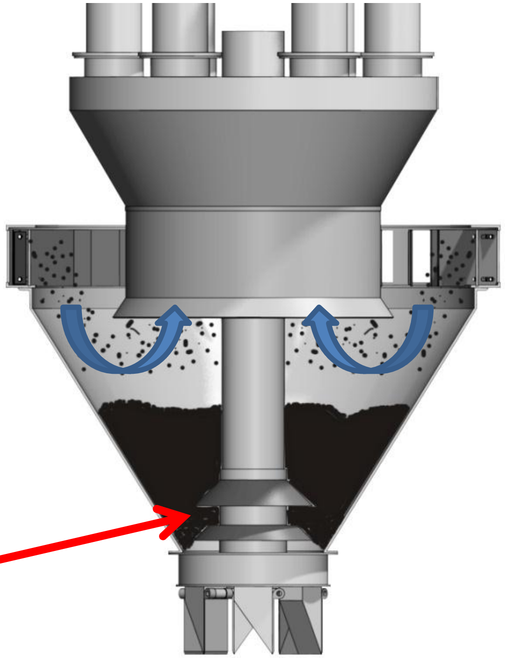


	Passing 50 Mesh	Passing 100 Mesh	Passing 140 Mesh	Passing 200 Mesh
Recommended	99.90	95.00	88.00	75.00
Pre-Outage Mill D	99.90	97.10	90.10	78.50
Post-Outage Mill D	99.20	87.20	74.10	60.40

Example: Poor Fineness After Outage due to:

- Maintenance setting classifier blades in fully retracted position after outage.
- Reject clearances set tight not allowing free returns of coarse particles .
- High air-to-fuel ratio due to PA flow indication error.

Coarse Returns Must Have a Free Flow Path for Regrinding

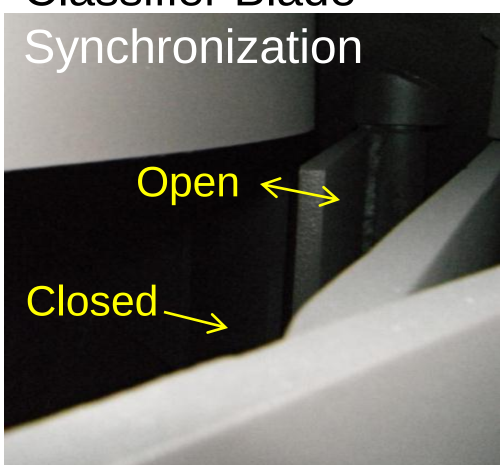


What could be wrong after the outage?

Some common incorrect settings after the overhaul causing poor performance:

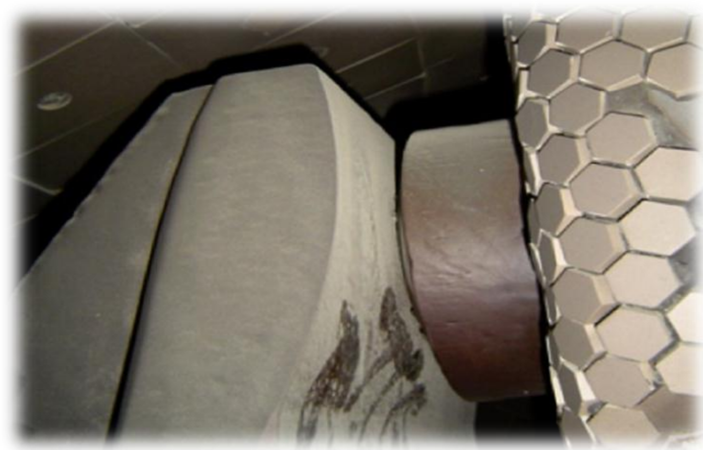
•Classifier blades setting
•Classifier blades unsynchronized
•Incorrectly set reject clearances
•Throat sizing
•Grinding element clearances/contours
•Spring settings
•Inaccurate PA indication
•Issues duplicated due to way it's been completed in the past

Classifier Blade Synchronization



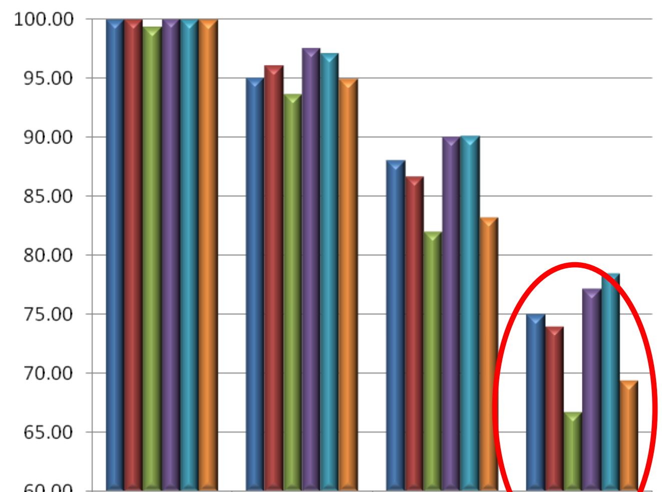
Classifier Blades Installed Upside Down

Proper "Button" Clearance

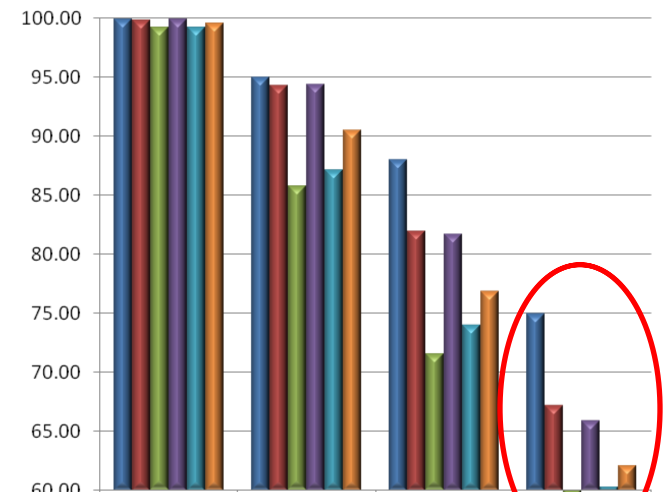


Pulverizer performance testing provides insight to operation and performance.

Same Settings ("Blueprinting") do not always = same fineness



	Passing 50 Mesh	Passing 100 Mesh	Passing 140 Mesh	Passing 200 Mesh
Recommended	99.90	95.00	88.00	75.00
Pre-Outage Mill A	99.89	96.03	86.64	73.96
Pre-Outage Mill B	99.30	93.59	82.03	66.73
Pre-Outage Mill C	100.00	97.50	90.00	77.20
Pre-Outage Mill D	99.90	97.10	90.10	78.50
Pre-Outage Mill E	99.90	94.90	83.20	69.40

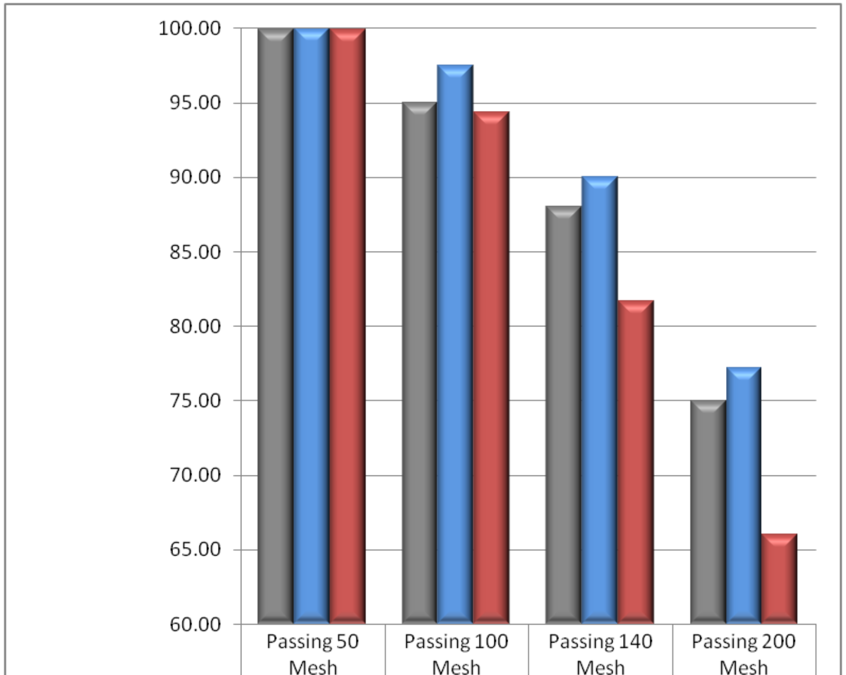


	Passing 50 Mesh	Passing 100 Mesh	Passing 140 Mesh	Passing 200 Mesh
Recommended	99.90	95.00	88.00	75.00
Post-Outage Mill A	99.84	94.31	81.98	67.26
Post-Outage Mill B	99.24	85.82	71.57	56.62
Post-Outage Mill C	99.90	94.40	81.70	66.00
Post-Outage Mill D	99.20	87.20	74.10	60.40
Post-Outage Mill E	99.60	90.50	76.90	62.20

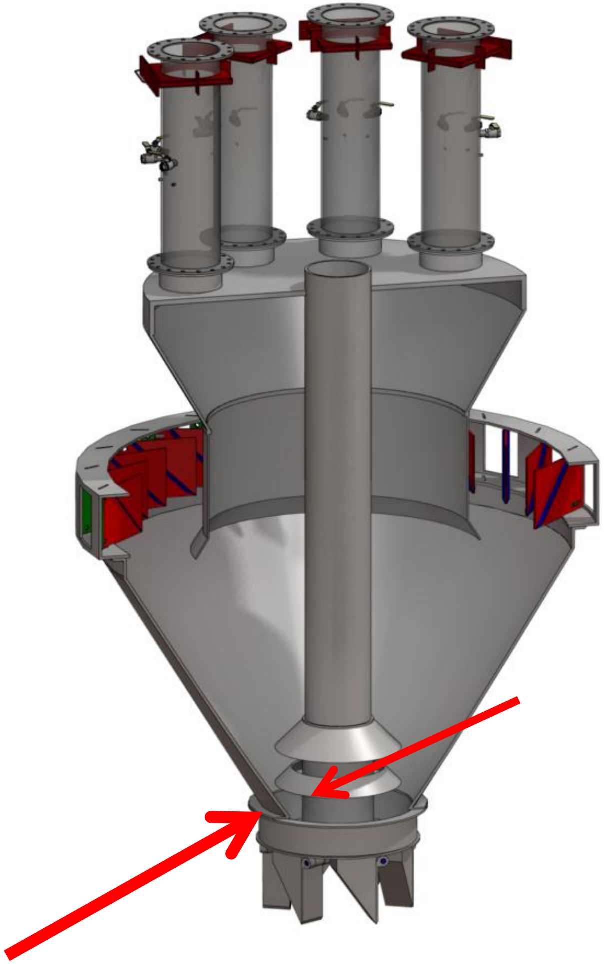
As shown here 200 mesh fineness is poor for every mill.
Issue was reject cone clearances were set to tight during an outage, not allowing proper recirculation.

Mill with Worst Performance was Concentrated On

Pre and Post Outage for ‘C’ Mill



	Passing 50 Mesh	Passing 100 Mesh	Passing 140 Mesh	Passing 200 Mesh
Recommended	99.90	95.00	88.00	75.00
Pre-Outage Mill C	100.00	97.50	90.00	77.20
Post-Outage Mill C	99.90	94.40	81.70	66.00



Clearance between classifier cone and reject cone too tight.

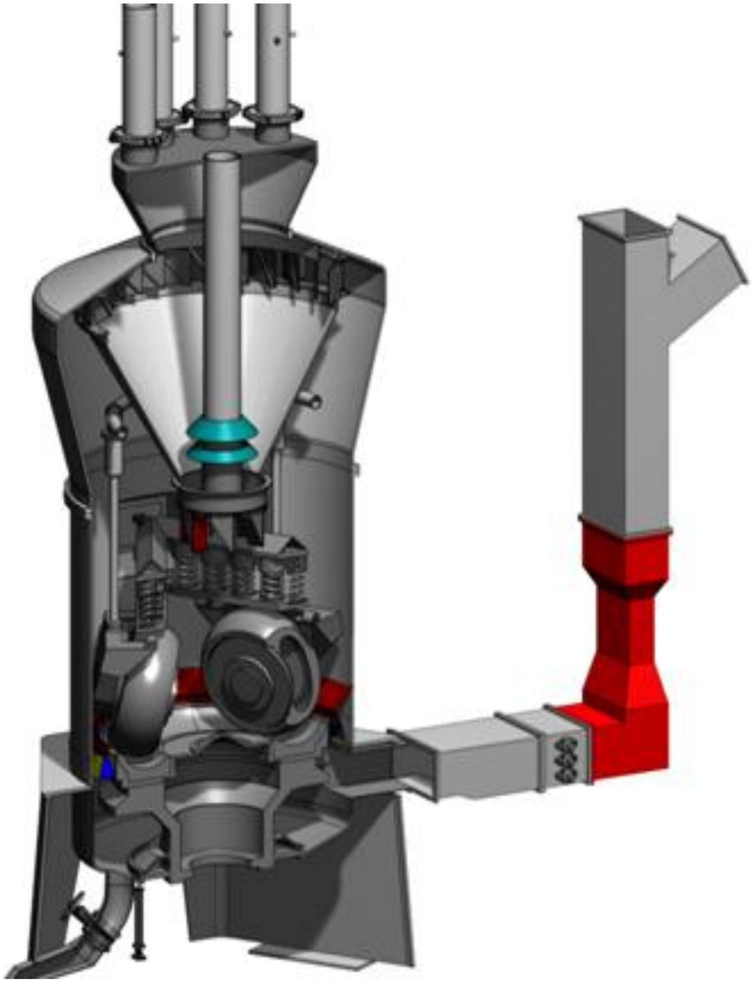
Proper Air/Fuel Ratio and Accurate Indicated Primary Air Flow

Properly maintained primary airflow and air-to-fuel ratios are a must.

The problem:
Decline in 200 mesh fineness

The suspect:
Inaccurate primary air resulting in a high A/F ratio

Resolution:
Next slide



Properly maintained airflow (PA curve, Air/Fuel ratio, Accurate indication ±3%) not only helps to ensure and maintain grinding performance but ensures:

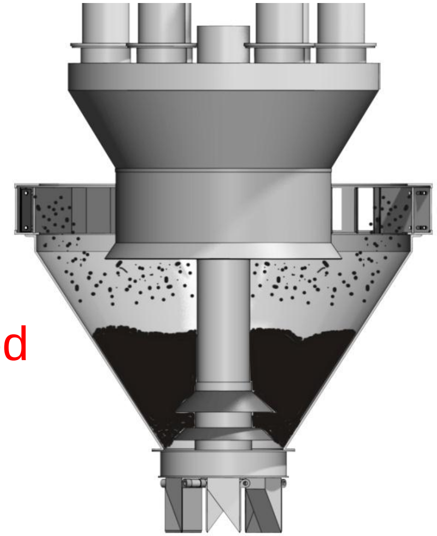
- Attached flames
- Improved fuel balance
- Lower CO levels
- Reduced Carbon in Ash (LOI)
- Reduced slagging and Fouling
- Correct design velocities in the classifier
- Increased retention time in grinding zone
- Reduced temperature "Peaks" at the Furnace Exit (Causes Slagging and Hot Tubes)

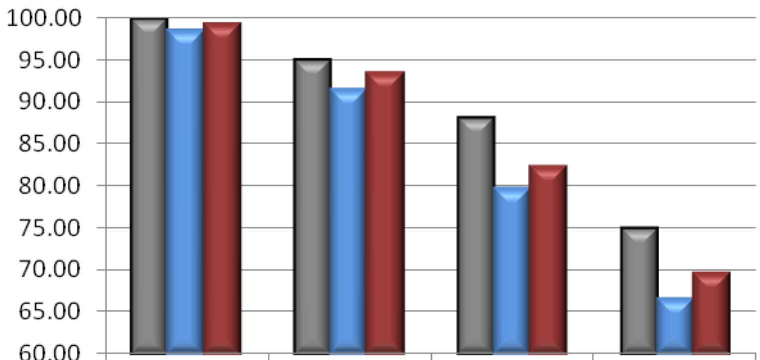
Proper Air/Fuel Ratio and Indicated Primary Air Flow

Suspected high PA indication was biased down to obtain the proper 1.8:1 A/F ratio

Test		Baseline	As-Left
Feeder Speed	%	80	80
Feed Rate	klb/hr	113	113
PA Flow	%	76	66
Measured Flow	klb/hr	248,633	209,218
Air/Fuel Ratio	lb/lb	2.20	1.85

1.8 preferred





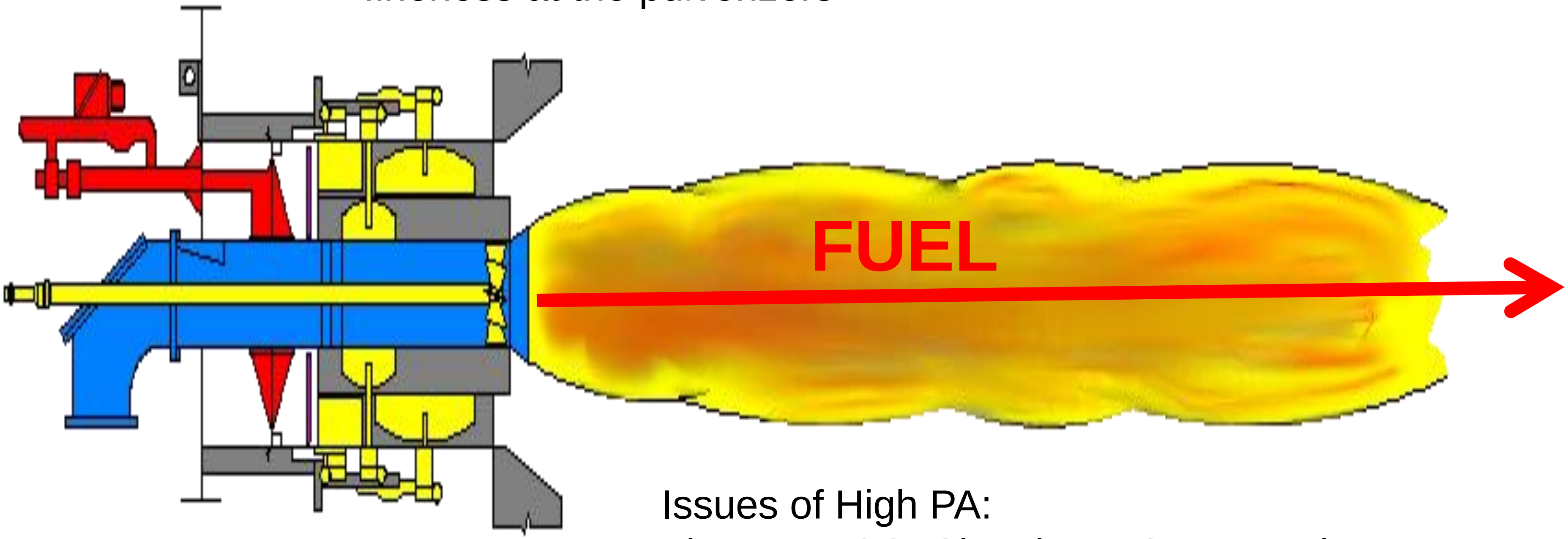
	Passing 50 Mesh	Passing 100 Mesh	Passing 140 Mesh	Passing 200 Mesh
Recommended	99.90	95.00	88.00	75.00
Baseline	98.50	91.40	79.60	66.50
Biased Primary Air	99.30	93.40	82.30	69.50

Iso-kinetic coal sampling test results showed improved fineness due to the increased retention time in the grinding zone.

Improved grinding performance with optimum air-to-fuel ratio.

Optimum Primary Airflow Matters at the Burners!

High Primary Airflow Contributes to Fuel "Out-running" the Secondary air at the burners, as well as contributes to poor coal fineness at the pulverizers

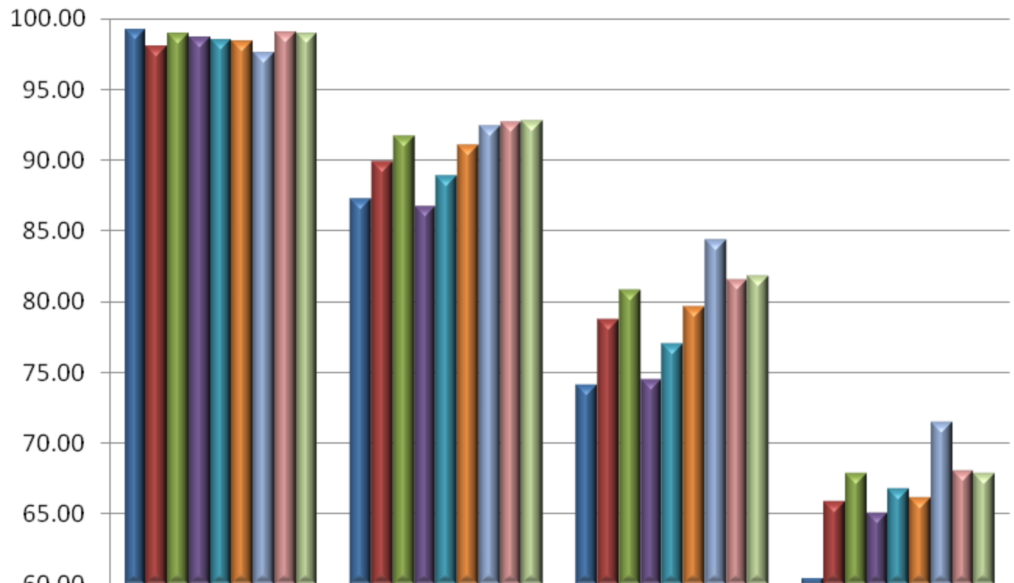


Issues of High PA:
Fineness, CO, Slagging, LOI, Hot Tubes, NOx, Fouling of SCR and ApH

Testing and Mechanical Tuning to Resolve the Problem

Problem:
Iso-kinetic coal sampling results after outage provided poor pulverizer fineness

Solution:
After several iterative solutions and Iso-kinetic testing the fineness was improved.

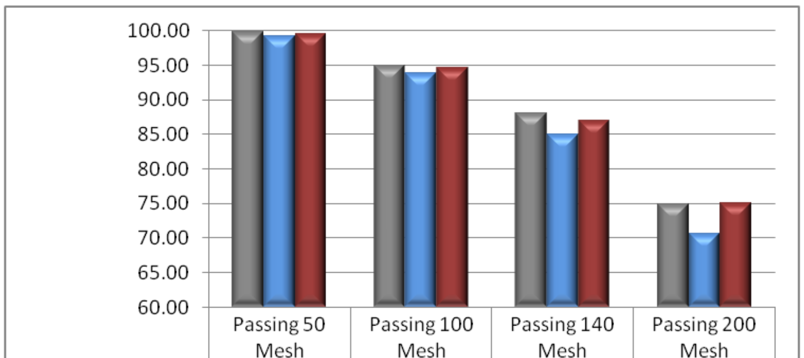


	Percent thru 50 Mesh	Percent thru 100 Mesh	Percent thru 140 Mesh	Percent thru 200 Mesh
Post-Outage	99.20	87.20	74.10	60.40
Blades all way in	98.00	89.90	78.70	65.90
Spring set@ 20.5”	98.90	91.70	80.80	67.90
No Adj	98.60	86.70	74.50	65.10
Adjusted reject clearances	98.50	88.90	77.00	66.80
Moved blades out 1½”	98.40	91.00	79.60	66.10
50% feeder speed	97.60	92.40	84.30	71.50
-5% PA flow	99.00	92.65	81.55	68.05
-10% PA flow	98.90	92.75	81.80	67.90

Performance Driven Maintenance Provides A Path to Achieve Results

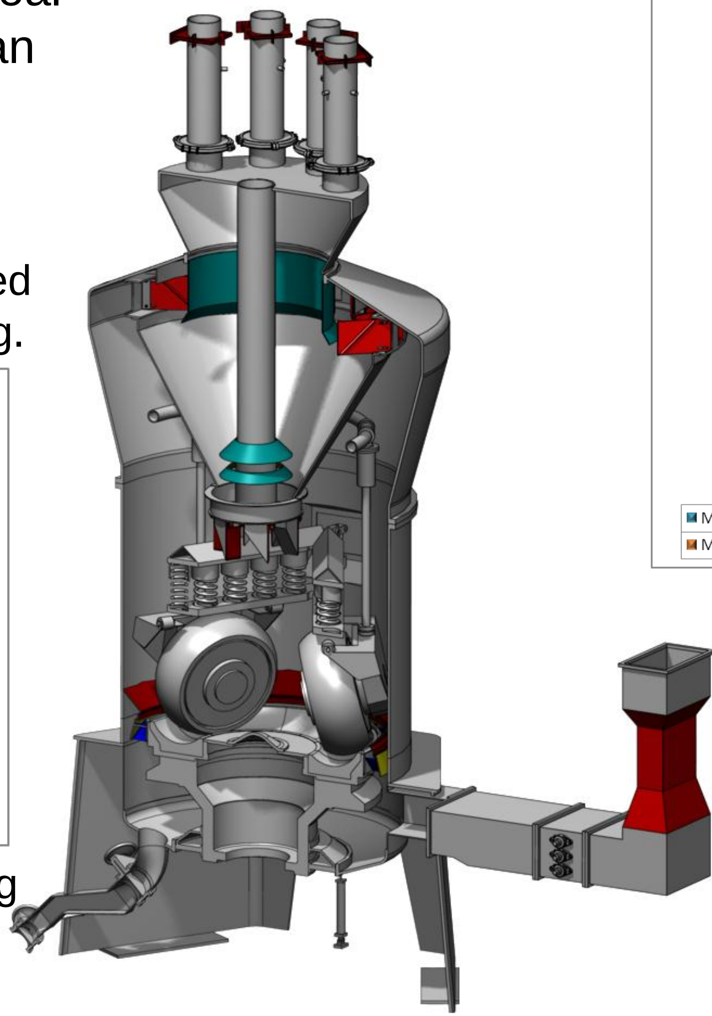
By conducting periodic Iso-kinetic coal sampling pulverizer performance can be tracked so that maintenance decisions are based on the truly important measurement.

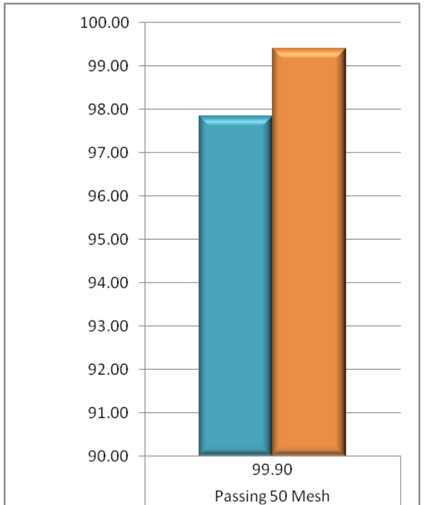
Issue: 200 mesh fineness had deteriorated over time which was monitored by testing.



	Passing 50 Mesh	Passing 100 Mesh	Passing 140 Mesh	Passing 200 Mesh
Recommended	99.90	95.00	88.00	75.00
Before	99.30	93.90	85.00	70.70
After	99.50	94.60	87.00	75.10

An improvement was made with calibrating the PA and a classifier adjustment.



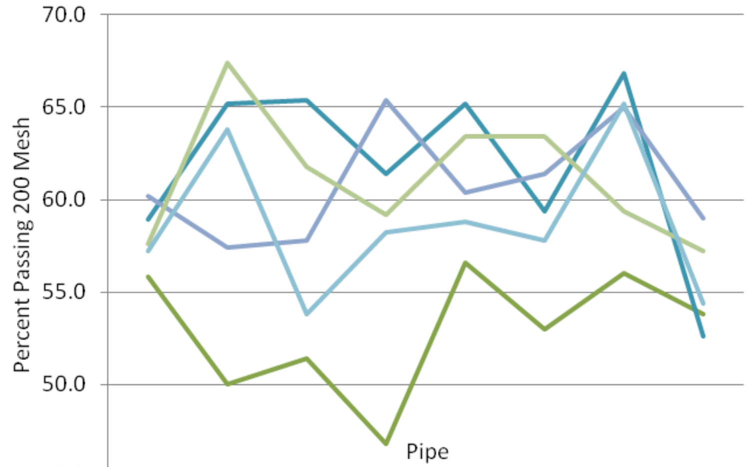


	99.90 Passing 50 Mesh
Mill C Test 1	97.84
Mill C Test 2	99.4

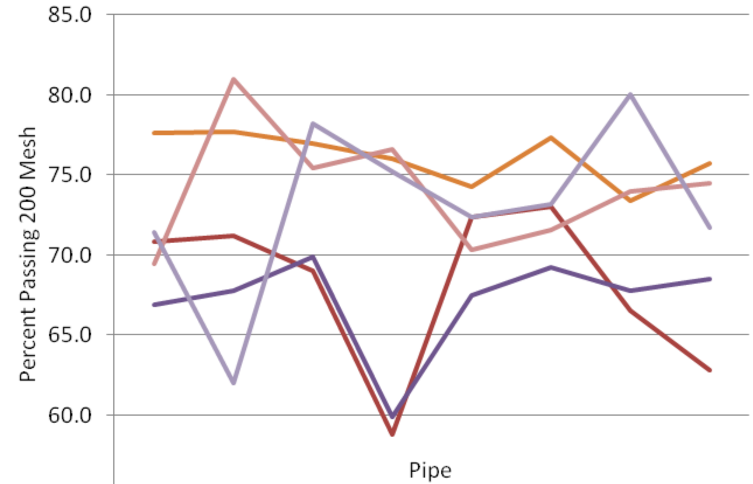
Improved 50 mesh by adjusting classifier blades.

Representative Testing is Required for Accurate Assessments

Results from this testing illustrates large fineness deviations from pipe to pipe. Non Iso-kinetic testing or not sampling all fuel lines can lead to unrepresentative results.



	1	2	3	4	5	6	7	8
Mill A Pre	55.8	50.0	51.4	46.8	56.6	53.0	56.0	53.8
Mill B Pre	58.9	65.2	65.4	61.4	65.2	59.4	66.8	52.6
Mill C Pre	60.2	57.4	57.8	65.4	60.4	61.4	65.0	59.0
Mill D Pre	57.6	67.4	61.8	59.2	63.4	63.4	59.4	57.2
Mill E Pre	57.2	63.8	53.8	58.2	58.8	57.8	65.2	54.4

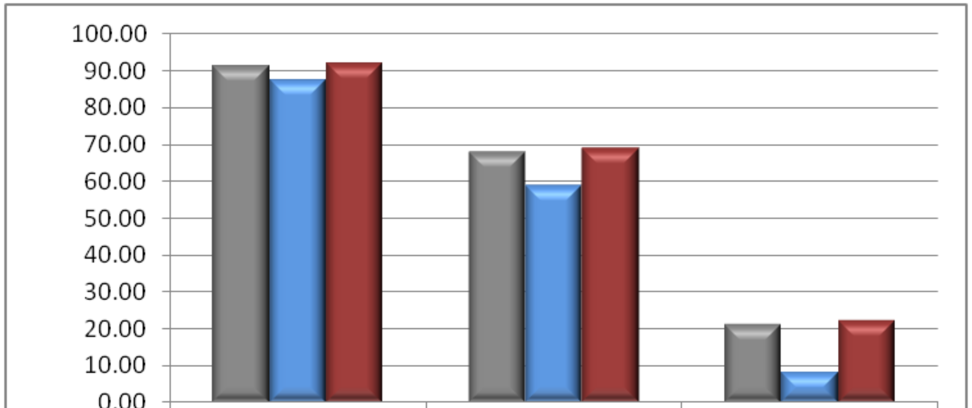


	1	2	3	4	5	6	7	8
Mill A Post	70.8	71.2	69.0	58.8	72.4	73.0	66.5	62.8
Mill B Post	66.9	67.8	69.9	59.9	67.5	69.2	67.8	68.5
Mill C Post	77.6	77.7	77.0	76.0	74.3	77.3	73.4	75.7
Mill D Post	69.5	81.0	75.4	76.6	70.3	71.6	74.0	74.5
Mill E Post	71.4	62.0	78.2	75.2	72.4	73.2	80.0	71.7

All coal pipes from a single pulverizer will usually have varied fuel fineness. Sometimes, widely varied. Testing all pipes is recommended.

Without Performance Driven Maintenance…..

Without performance driven maintenance pulverizer performance could look like this….



	%Passing 50 Mesh	%Passing 100 Mesh	%Passing 200 Mesh
Mill 4-3	91.42	67.88	21.22
Mill 4-1	87.56	58.83	8.24
Mill 4-2	91.84	68.86	22.30

This was a ball tube mill and the issues started with reject lines were not working properly, classifier blades out of synchronization, +3" on crusher dryer clearances.

In Conclusion

- Overhauls do not guarantee good performance
- Performance must be monitored by testing
- Monitoring performance with testing can lead to lower production costs
- Applying the basics and paying attention to the details are pre-requisites for acceptable combustion performance

(3) Part Flyash Sieve/LOI Analysis

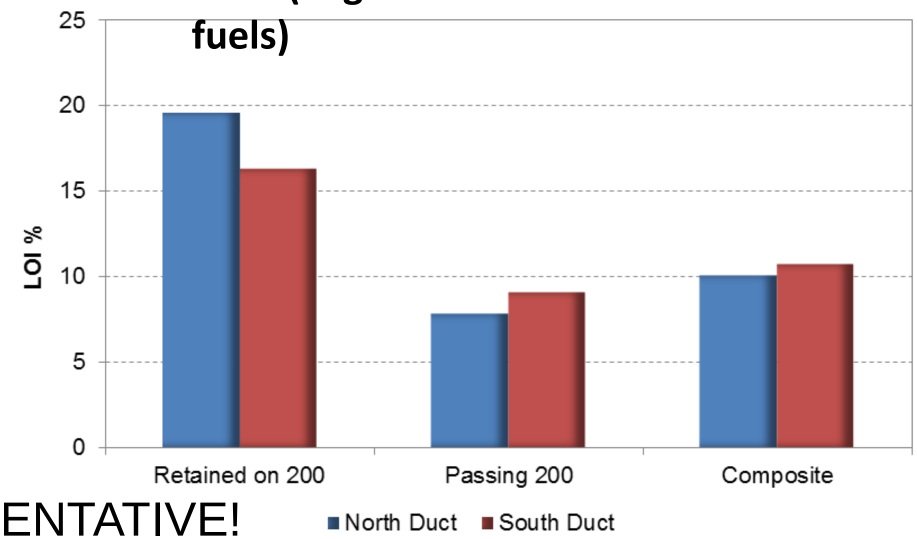
200 MESH SIEVE (COARSE ASH)

BOTTOM PAN (FINE ASH)

Place 50 grams of ash on the 200 MESH for sieve analysis

DETERMINE L.O.I. OF RESIDUE ON 200 MESH SCREEN AND IN PAN

L.O.I. OF FINE ASH MUST BE LESS THAN 2% (low volatile eastern fuels); or less than 0.5% (high volatile western fuels)



This is a Test to "Referee" the cause of Objectionable Flyash LOI

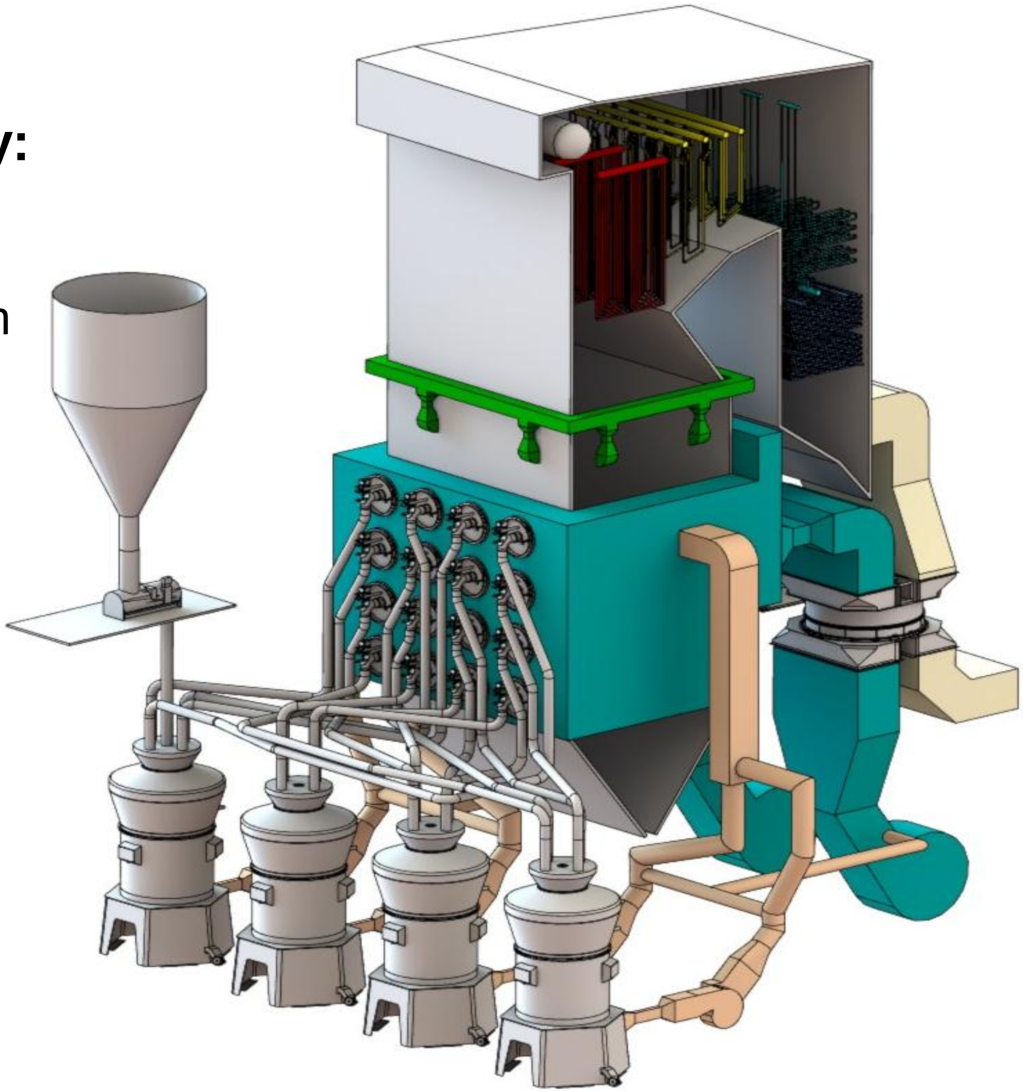
To attribute "Root Cause", to Mills or Other

Caution! The ash sample must be REPRESENTATIVE!

Pulverizers are the Heart of a Pulverized Coal Fueled Boiler

Optimum Combustion Today:

- Maximum Capacity
- Competitive cost fuel (Fuel Flexibility) Now Competing with Natural Gas
- Minimum Slagging
- Minimum Fouling
- Minimum Carbon in ash
- Low CO at furnace/boiler exit
- Good Load Response
- Design Steam temperatures
- Minimum sootblowing
- Least Waterwall wastage
- Minimum Reheat Sprays
- Best Heat-Rate possible



Closing Suggestion… First, Apply the Basics

THANK YOU!

Richard (Dick) Storm, PE

Adam C. McClellan,PE

Jesse Parnell

Danny Storm

Storm Technologies, Inc.

Albemarle, NC

Richard.Storm@stormeng.com

www.stormeng.com