एनटीपीसी लिमिटेड
(भारत सरकार का उद्यम)
NTPC Limited
(A Govt. of India Enterprise)

Pulverizer Plant O&M Aspects

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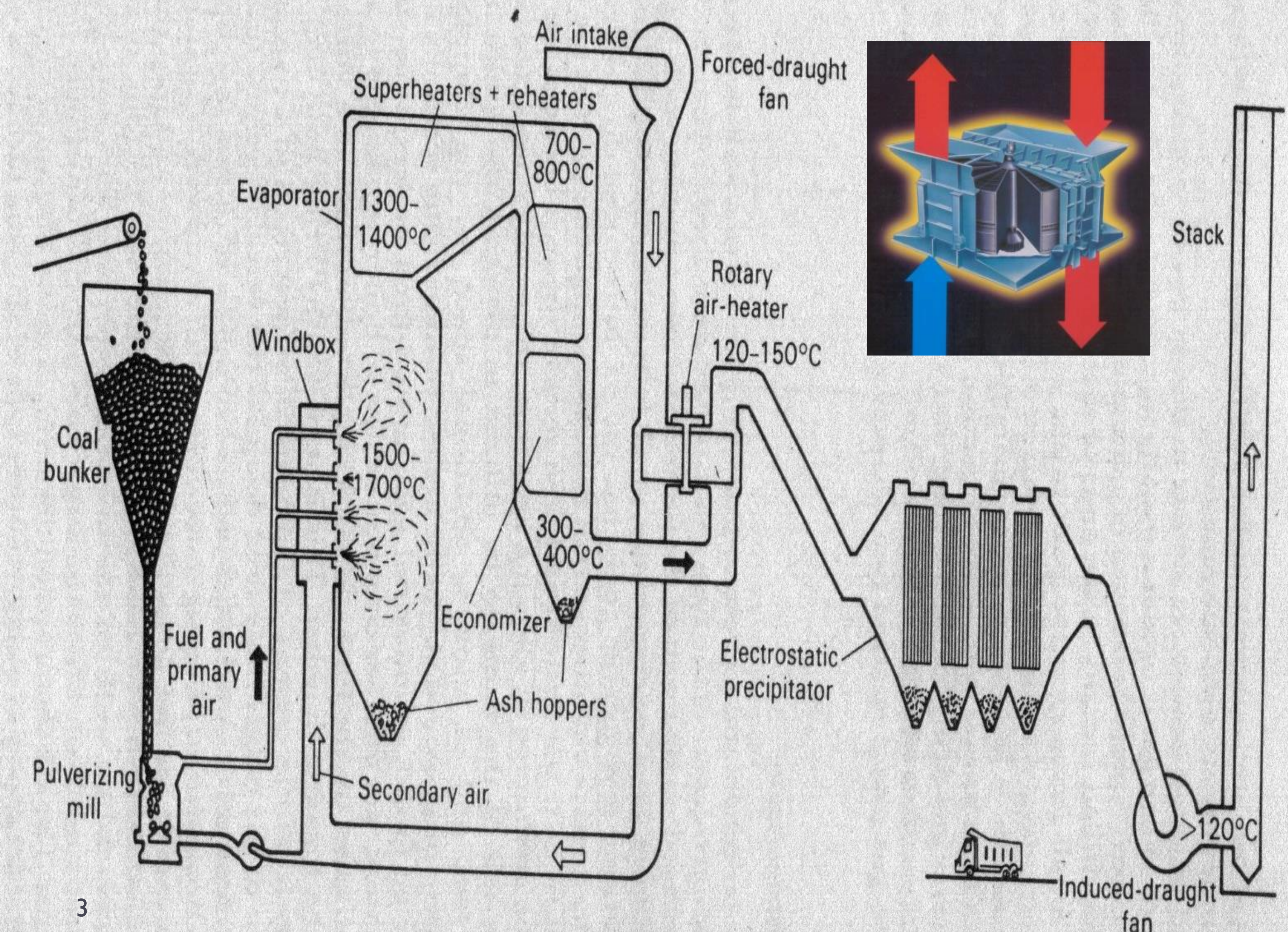
Contents

- Coal characteristics, fineness, combustion interrelationship
- Mill operational issues
- Constructional features and maintenance
- Performance issues and case studies


Air intake
Forced-draught fan
Superheaters + reheaters
700–800°C
Evaporator
1300–1400°C
Windbox
1500–1700°C
Coal bunker
Fuel and primary air
Pulverizing mill
Secondary air
Economizer
300–400°C
Ash hoppers
Rotary air-heater
120–150°C
Electrostatic precipitator
Stack
>120°C
Induced-draught fan

The Three Ts & One S Practice

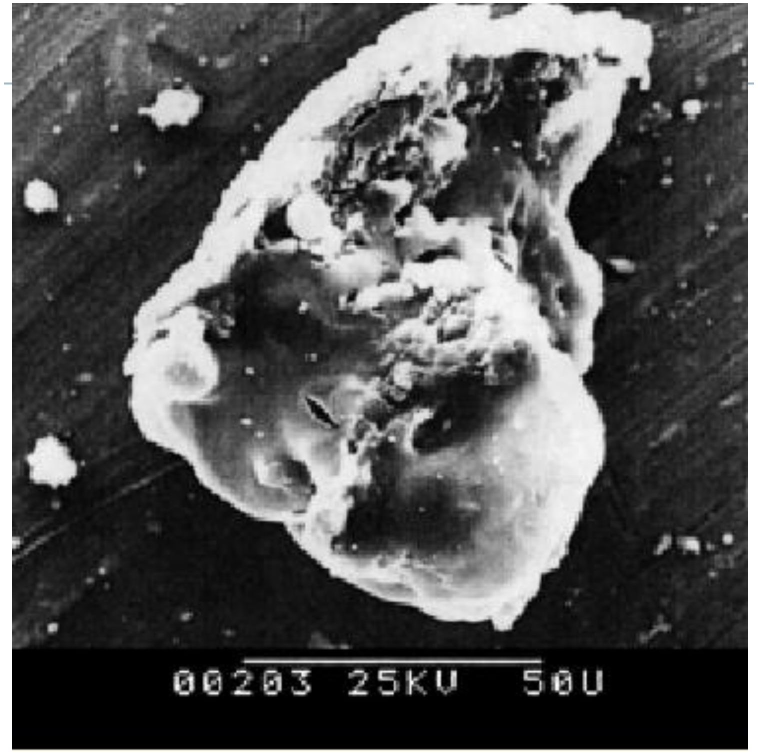
Technology ↓	Time	Temperature	Turbulence	Size
Stoker	**large**	**Medium**	**Low**	**Big**
Pulverized	**Short**	**High**	**Medium**	**Tiny**
Cyclone	**Short+**	**V High**	**High**	**Medium**
Fluid Bed	**Medium**	**Low**	**High**	**Medium**

Size the Coal and Add the Air !!!

Coal – an organic complex polymer

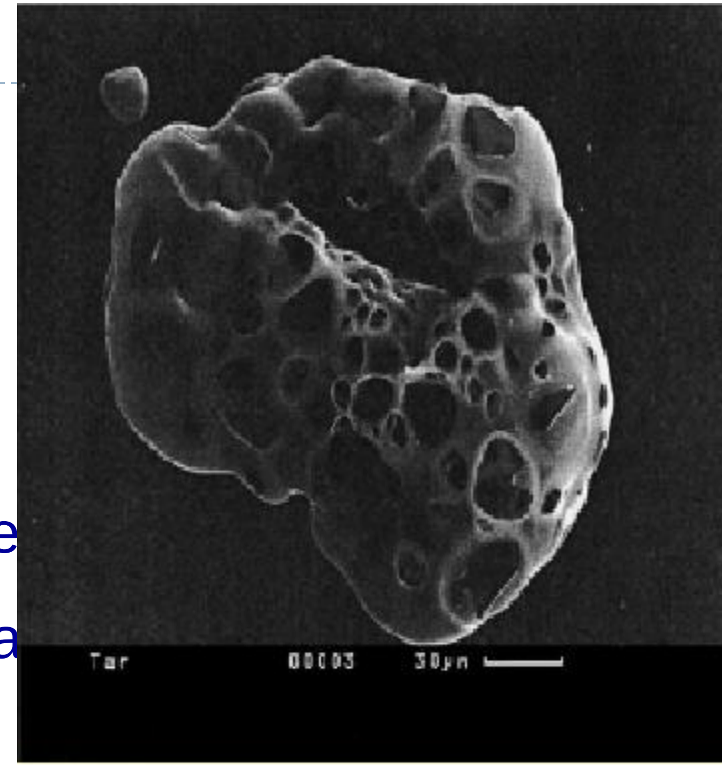
Sequential events

- Devolatilization (Pyrolysis)
  - Heating causes its structure to decompose
  - Weaker chemical bonds break at lower temperatures
  - Stronger ones at higher temperatures
  - Volatile yield can be up to 50% greater than indicated by proximate analysis



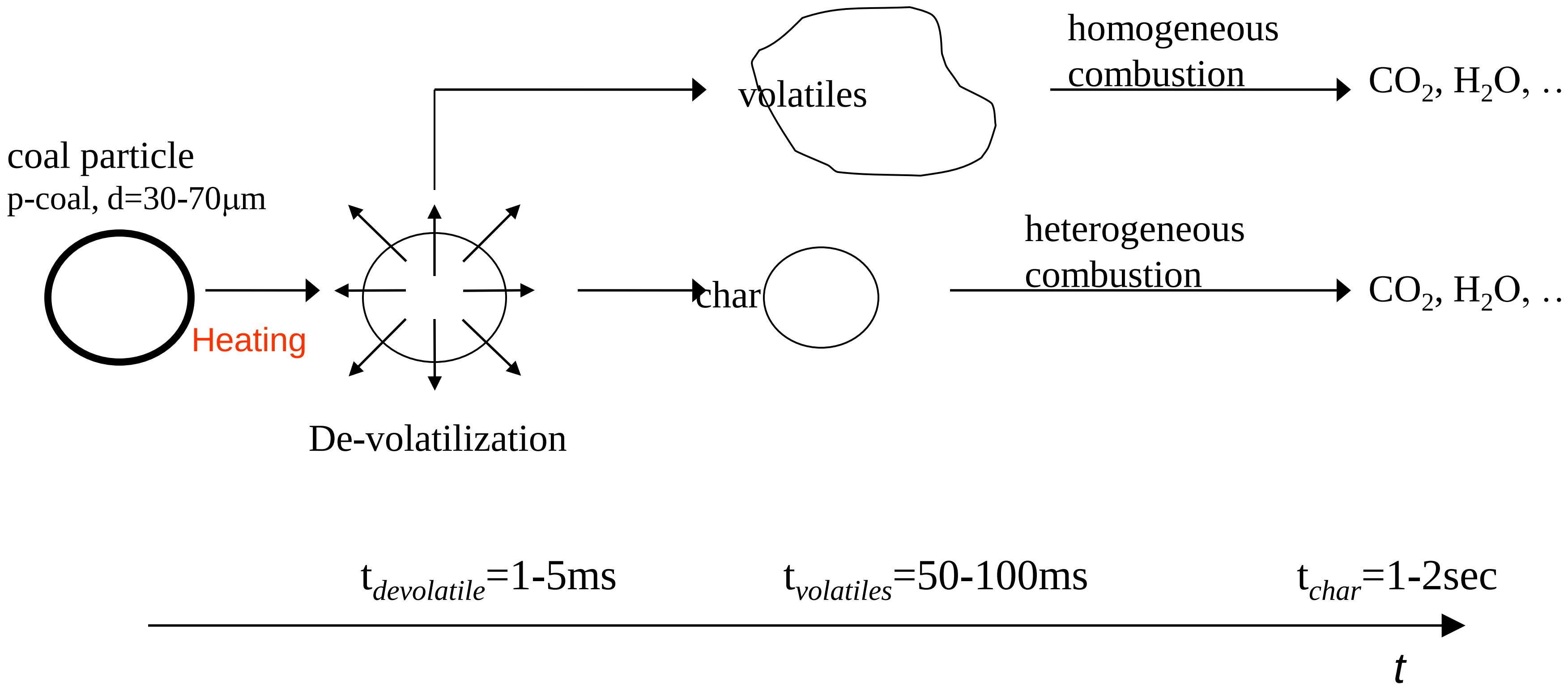
SEM of a de-volatilizing coal particle

- Burning of volatile matters
  - Homogeneous gas phase reaction around the particle
- Char burning
  - Heterogeneous combustion
  - Occurs at the char surface and pore surfaces (porosity~0.7; surface area ~100 m^2/g)
  - Guided through competing effects of heat and mass transfers to the char surface and chemical reaction



Char particle at the early stage of burning

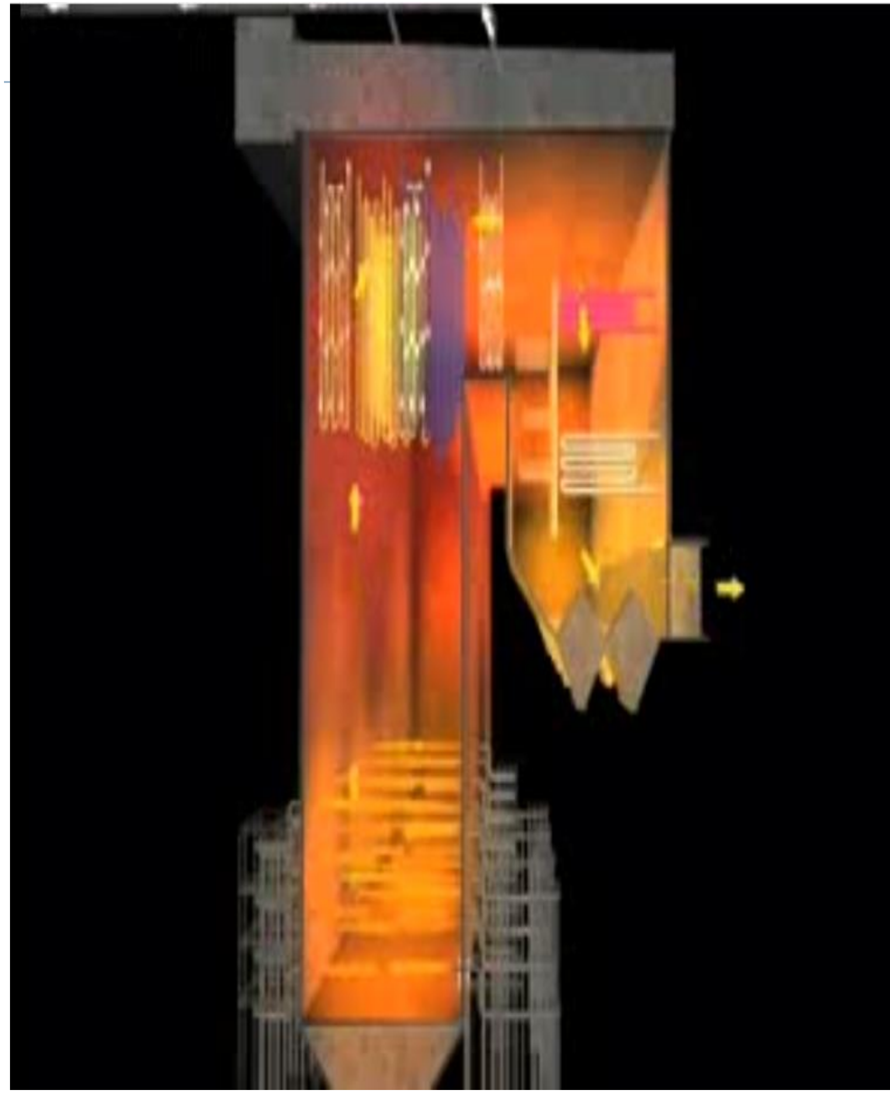
Coal Combustion



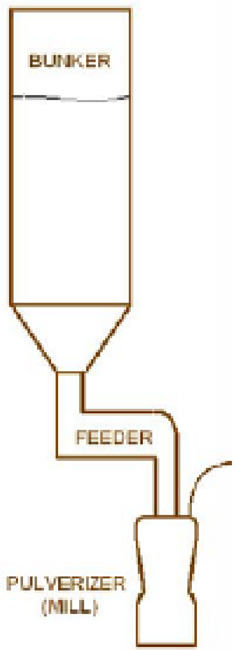
Temperature, Turbulence, **Time** and Size

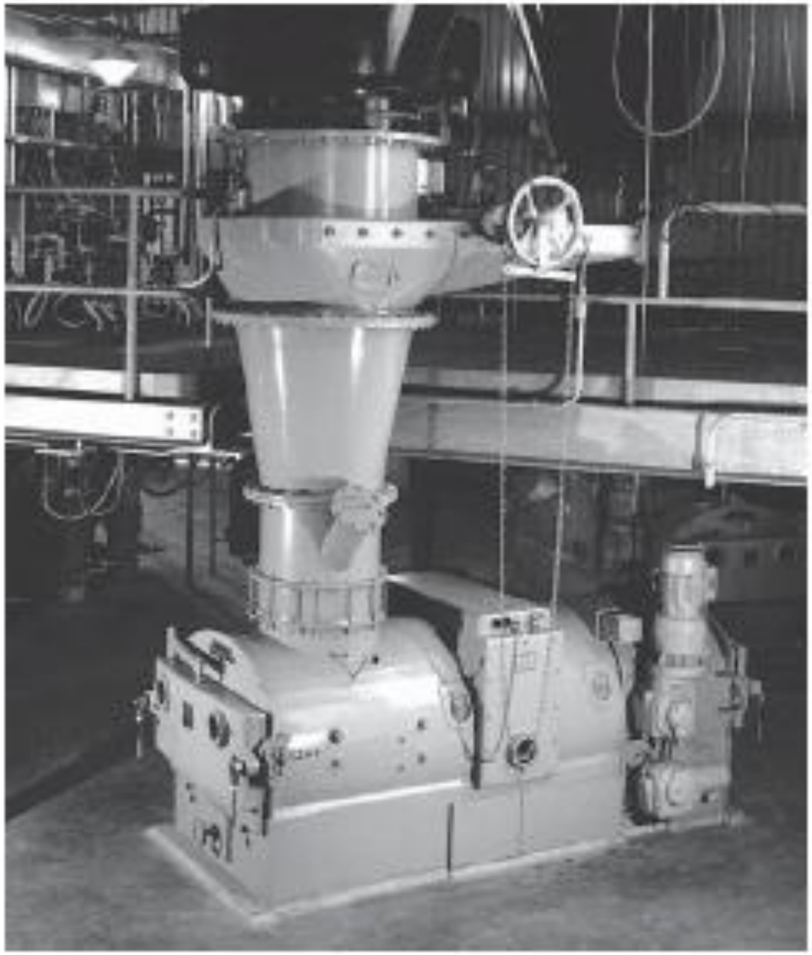
VM, Fineness, Combustion & Residence Time

- Vol. combustion intensity, I_v is in the range 150-250 kW/m^3.
- FEGT<IDT
- For a desired I_v, one can select t_r (~ 2 sec)
- The combustion time, t_c (~ 1 sec) <t_r by a significant margin.
- Low VM coal; more fineness required



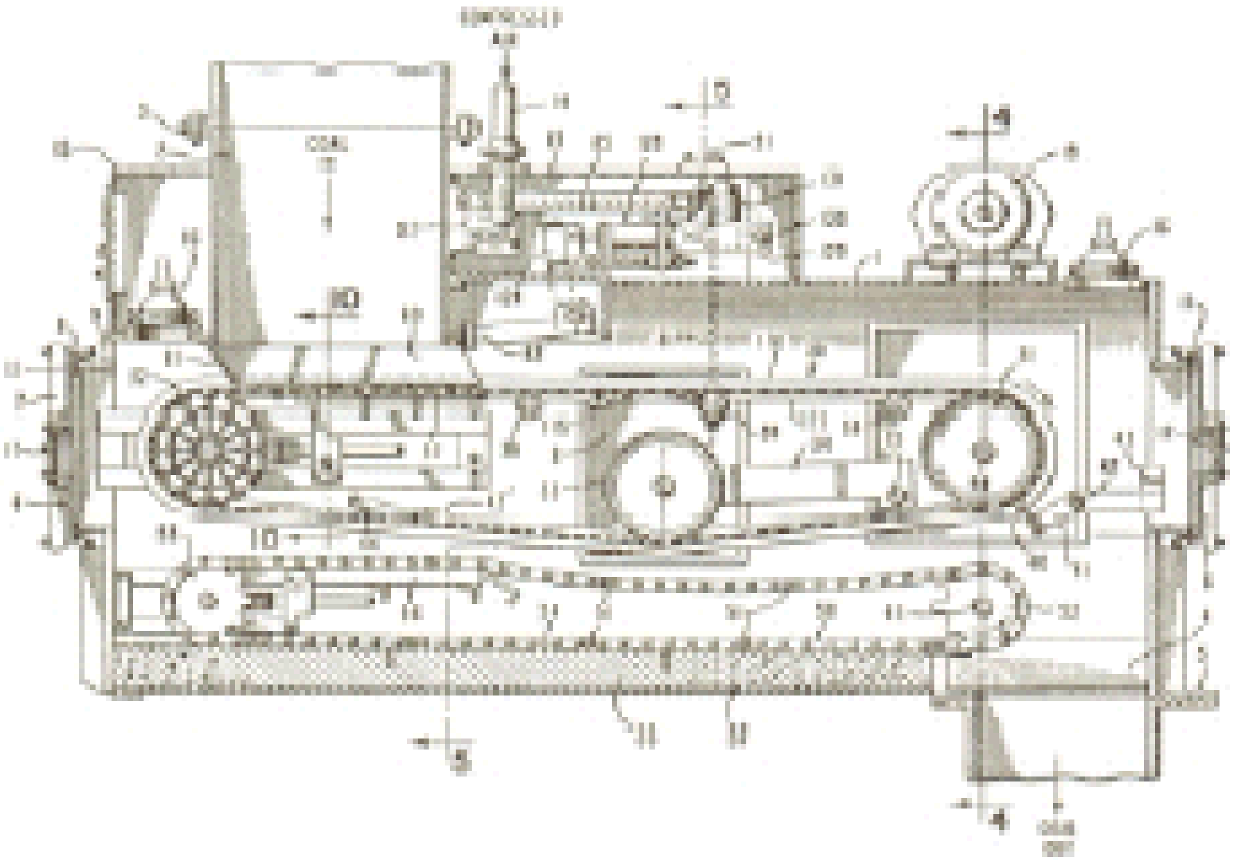
Gravimetric Feeder



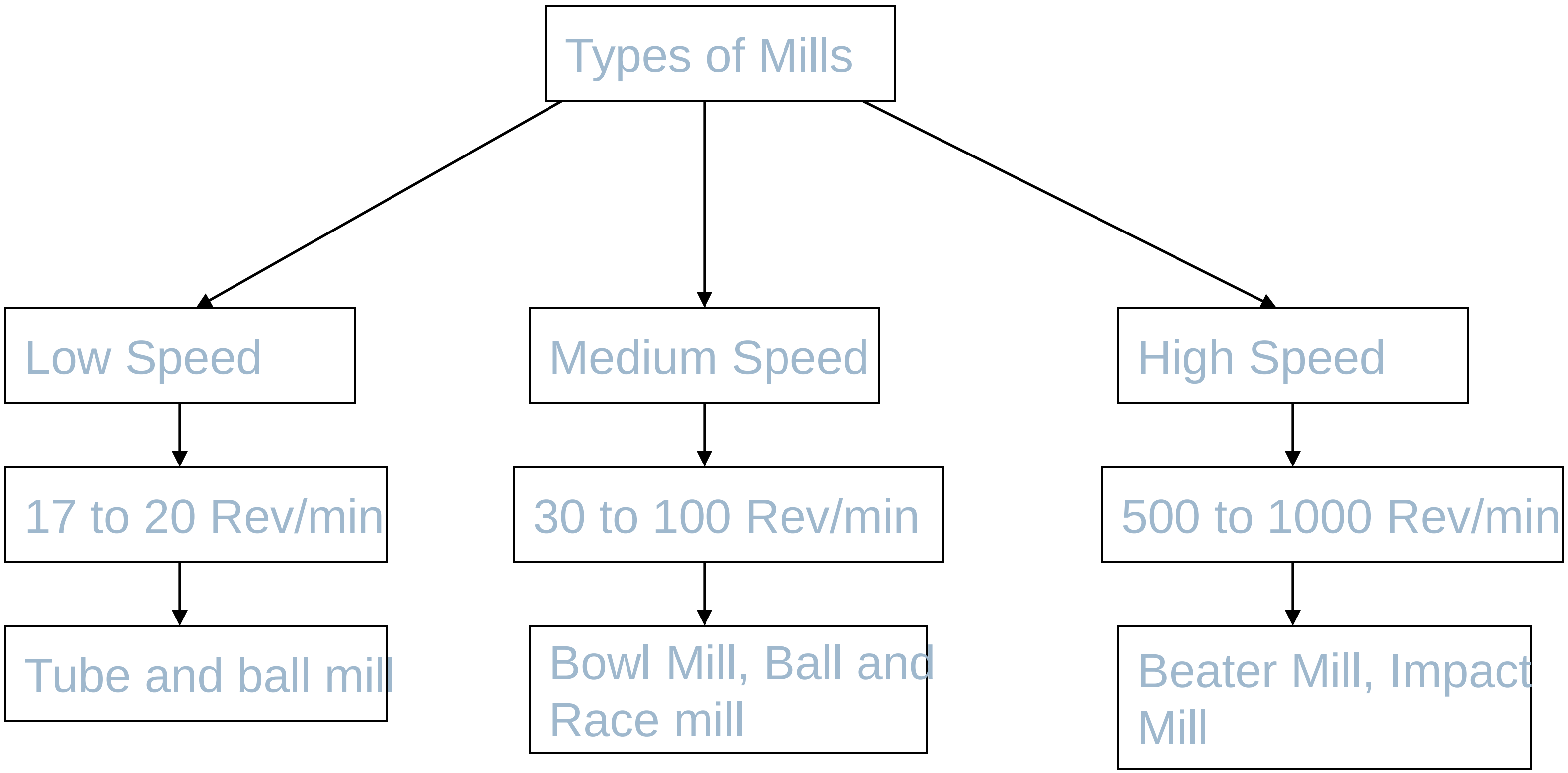


Gravimetric Coal feeder

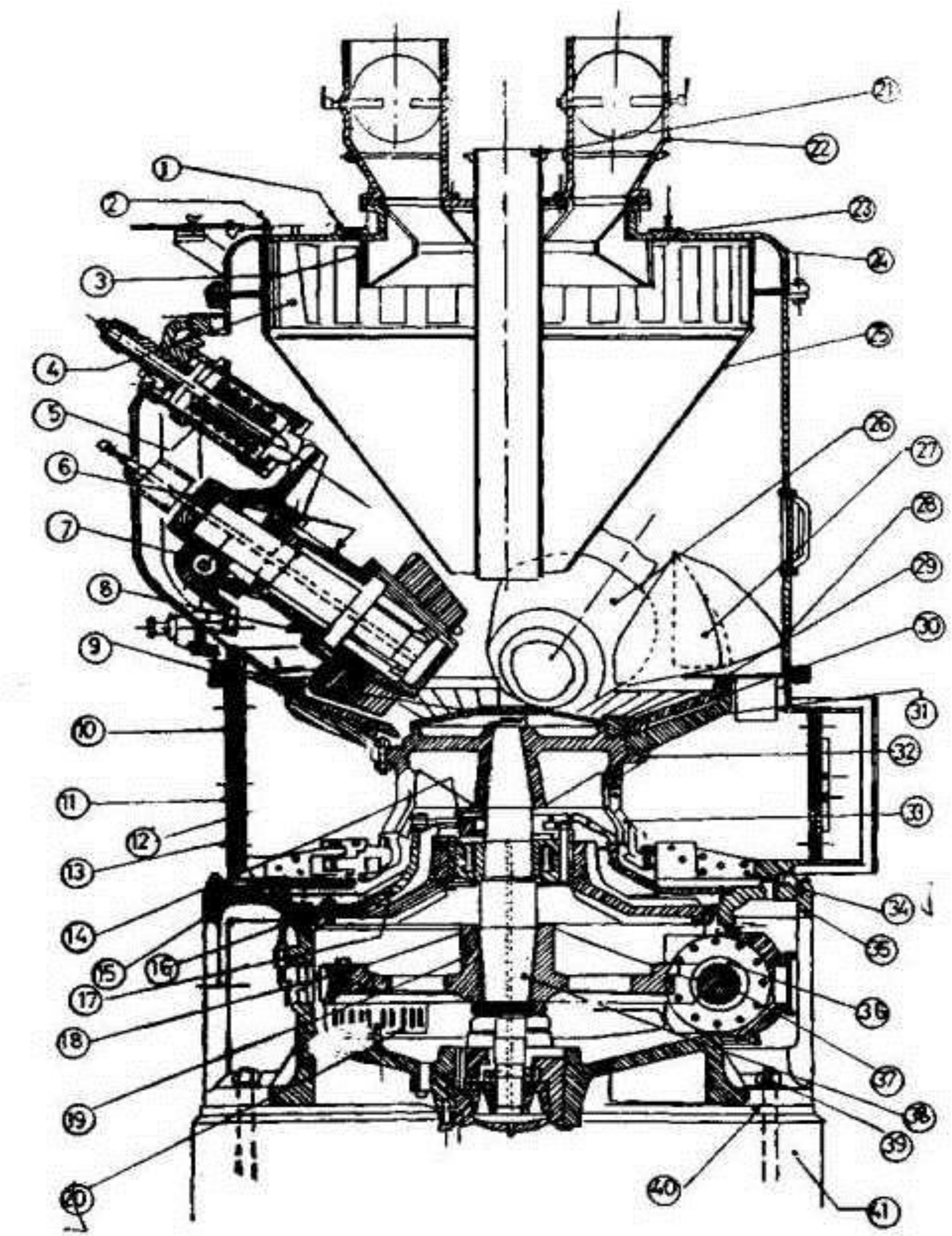
Internals of coal feeder



Classification-As per Speed



BOWL MILL



Model no.	Base capacity(T/Hr)
623XRP	18.4
703XRP	26.4
763XRP	33.8
803XRP	36.5
883XRP	51.1
903XRP	54.1
1003XRP	68.1
1043XRP	72.0

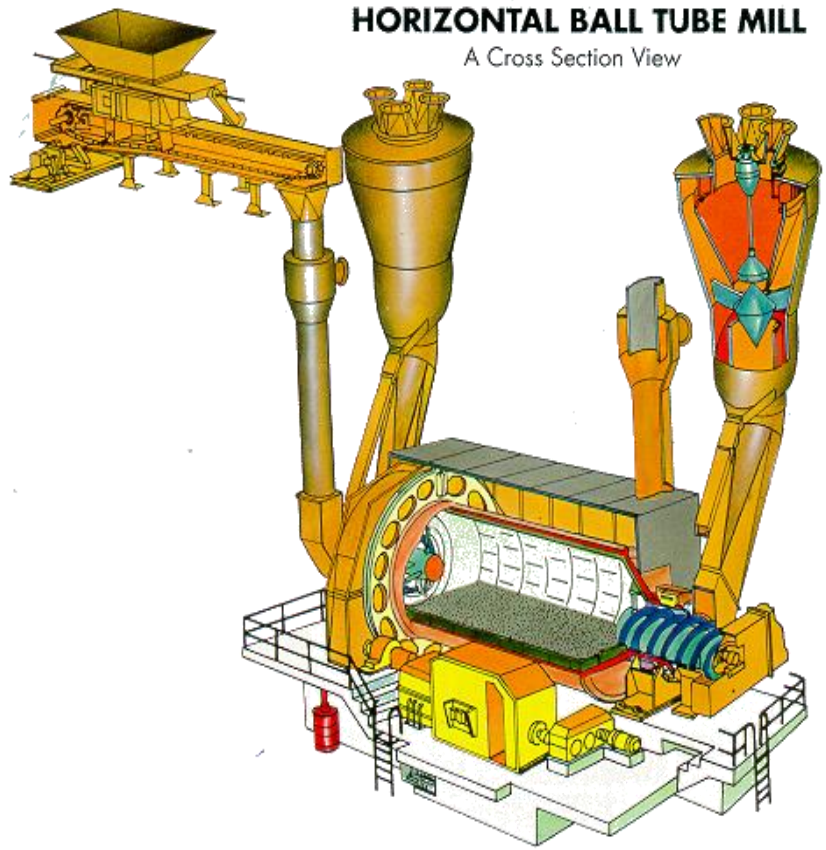
BASE CAPACITY(T/HR)
AT
HGI -55
Total Moisture-10%
Fineness-70% THRU 200 MESH

Types of pulverisers

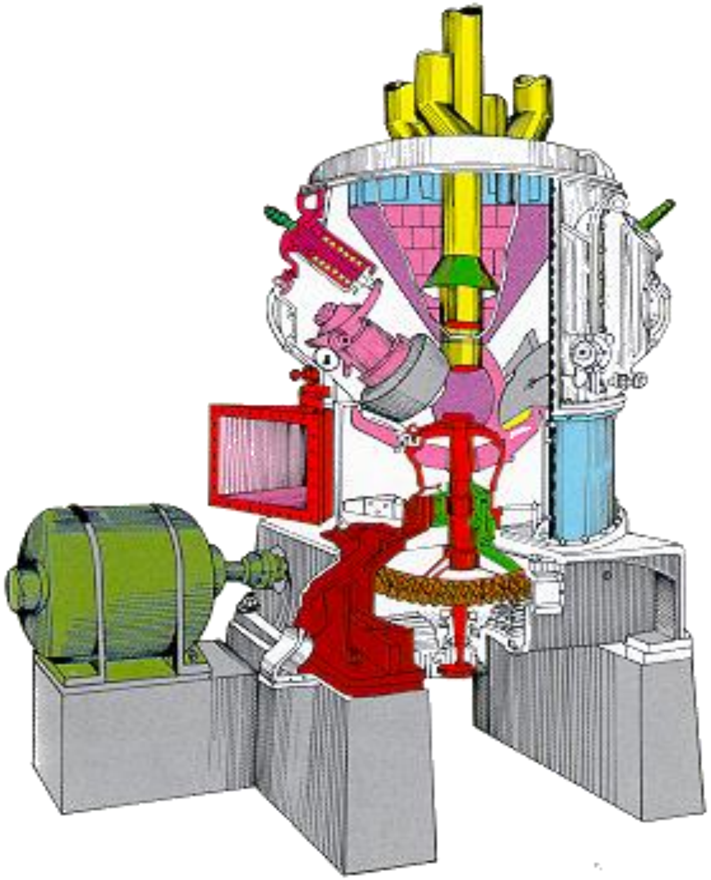
- Based on principles of particle size reduction
  - Impact
  - Attrition
  - Crushing
- Pulverisers use one, two or all the three principles.

Types of pulverisers

Speed	Low 10 to 20 rpm	Medium 40 to 70 rpm	High 900 to 1000 rpm
Type	Ball tube mills	Bowl Mill Ball & race Mill	Hammer mill, beater mill or fan mill
Dominating Principal	Attrition	Crushing	Impact



Tube mill



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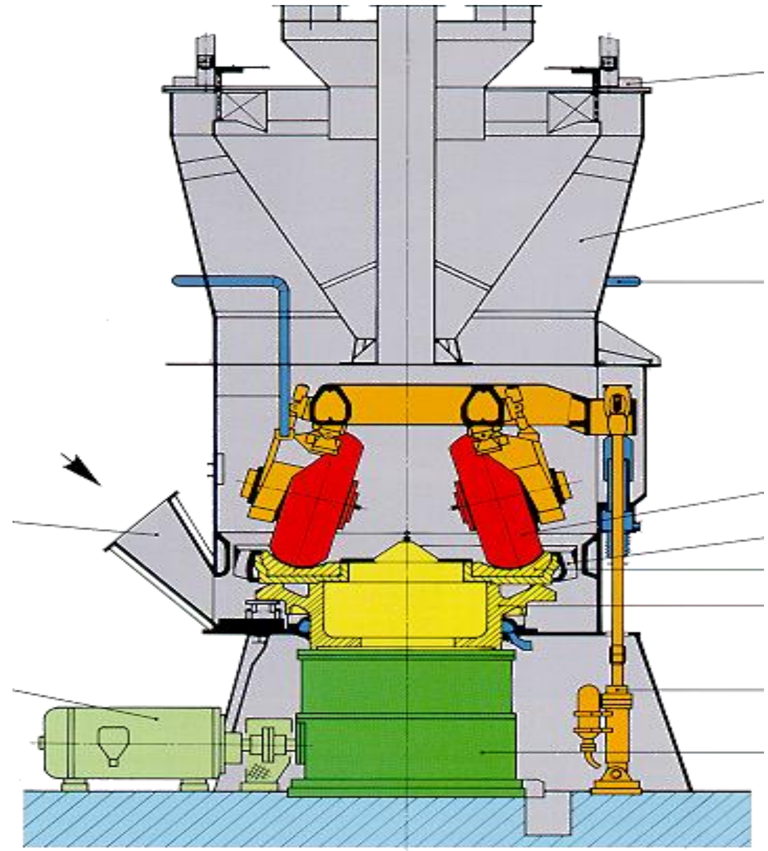
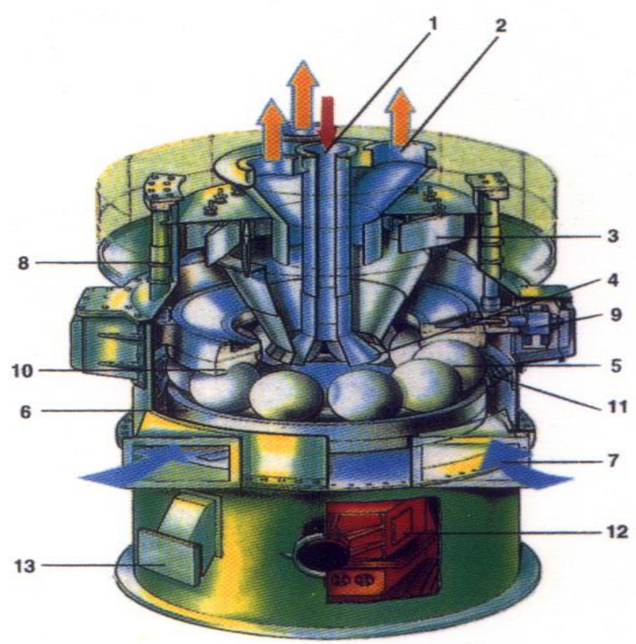


MPS MILL



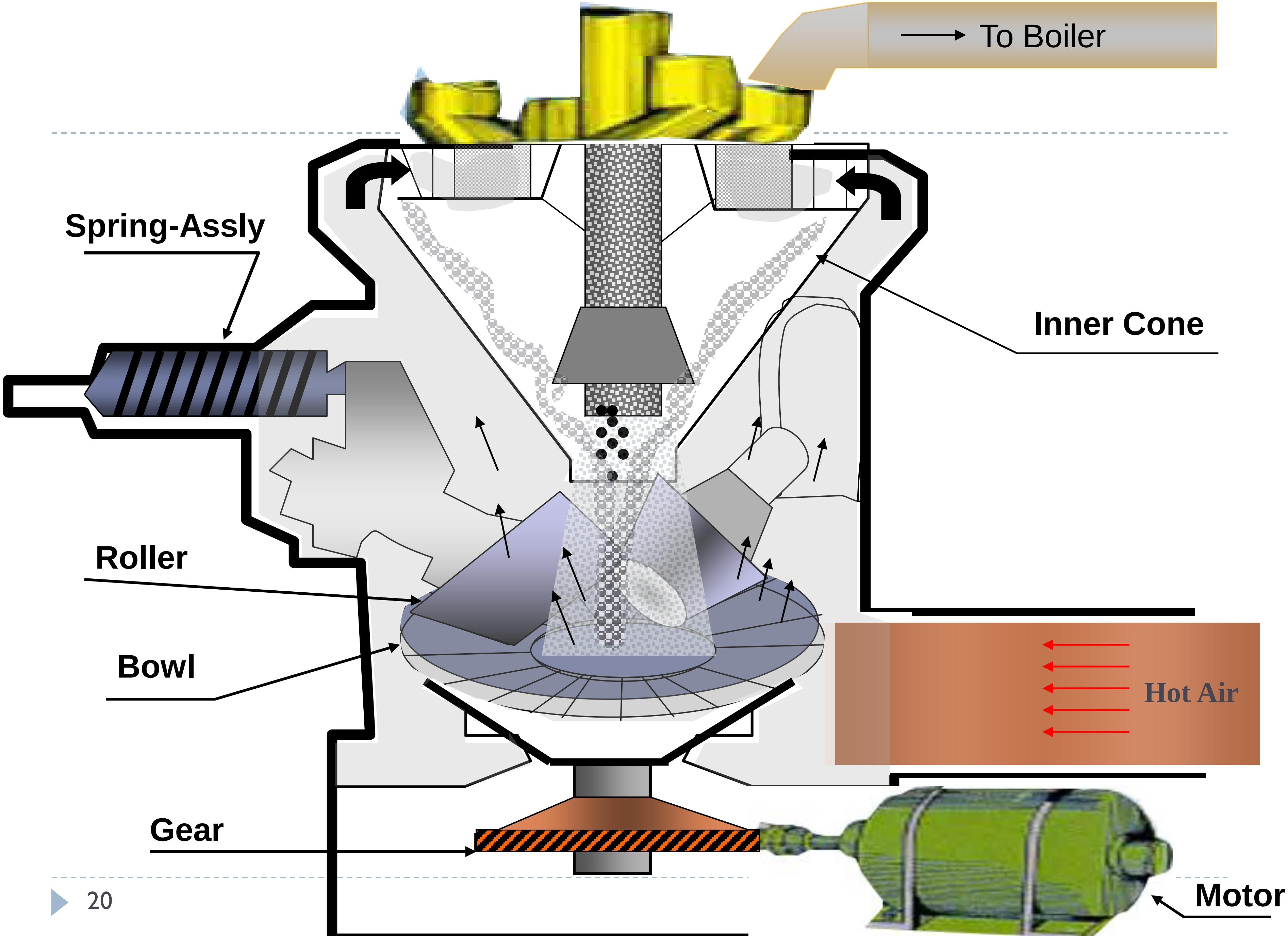
Key Features

1 Raw Material Inlet
2 Product Outlet
3 Adjustable Classifier Blades
4 Oversize Particles Return Chute
5 Hollow Balls
6 Rotating Lower Grinding Ring
7 Primary Air Inlet
8 Loading Cylinders
9 Spider Guides
10 Stationary Upper Grinding Ring
11 Throat Plate
12 Gearbox
13 Reject Box

Ball & Race Mill

Nomenclature-Bowl Mills

- 583 XRS / 803 XRP Bowl mills
- 58,80 stands for bowl diameter in inches
- If the number is even then its shallow bowl mill.
- If the number is odd then its deep bowl mill
- 3 - number of rollers three nos.
  - X - frequency of power supply 50 cycles. In USA 'x' means 60 cycles.
  - R- Raymond, name of the inventor
  - S- suction type with exhauster after mill
  - P- pressurised type with P.A. Fan before mill.


To Boiler
Spring-Assly
Inner Cone
Roller
Bowl
Hot Air
Gear
Motor

Factors affecting Mill performance

- Moisture in the coal.
- Coal grindability index.
- Mill inlet and outlet temp.
- Mill differential Pr. (DP)
- Mill loading.
- Air Flow in the Mill.
- Mill Motor current.
- Coal Mill fineness

- Grindability
- Moisture content
- Fineness
- Pri air quantity & temp

Effect of Grindability

- The grind ability of the coal is an empirical index
- It is not an inherent property of coal
- Relative ease of grinding as compared with standard coal
- It is determined in laboratory using 50 g of air dried sample of properly sized coal in a miniature pulveriser which is set to rotate exactly 60 revolutions grinding the coal sample.
- The hard grove Gindablility index is calculated
  - **G.I. (hardgrove) = 13+6.93W**
  - **Where W= weight of dust passing through 200 mesh sieve.**

Effect of Grindability

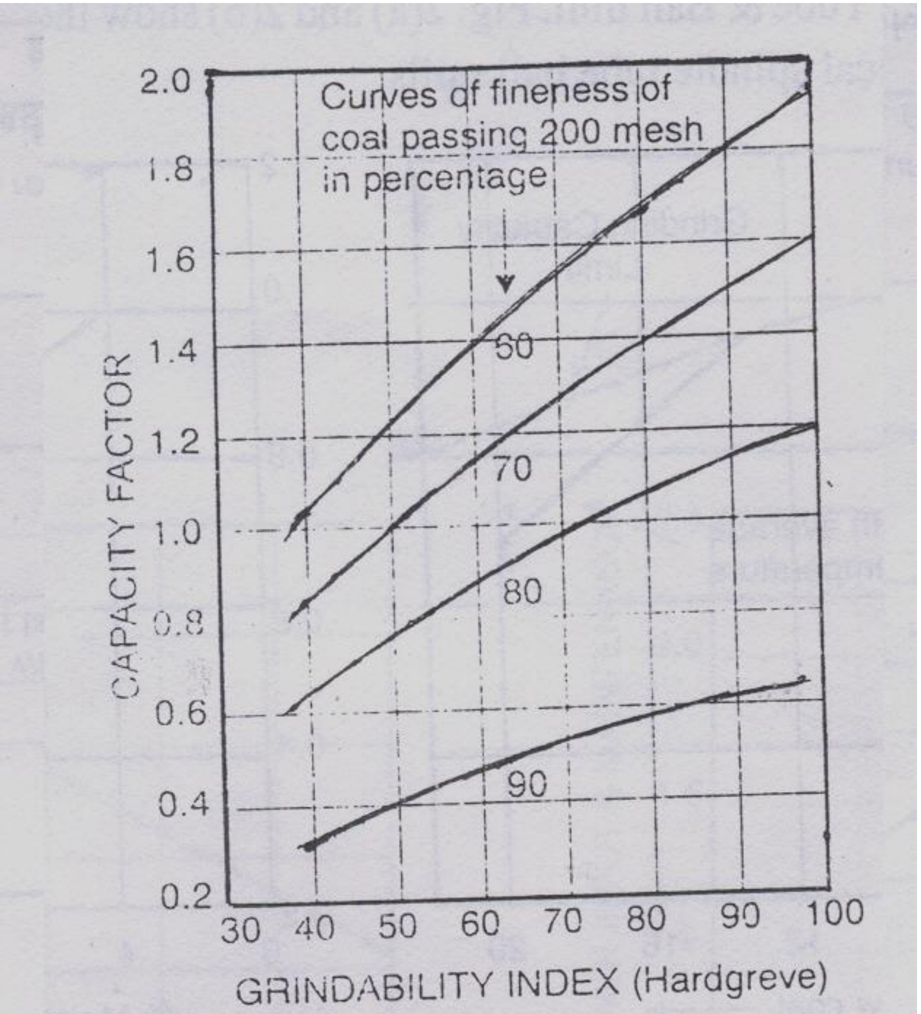
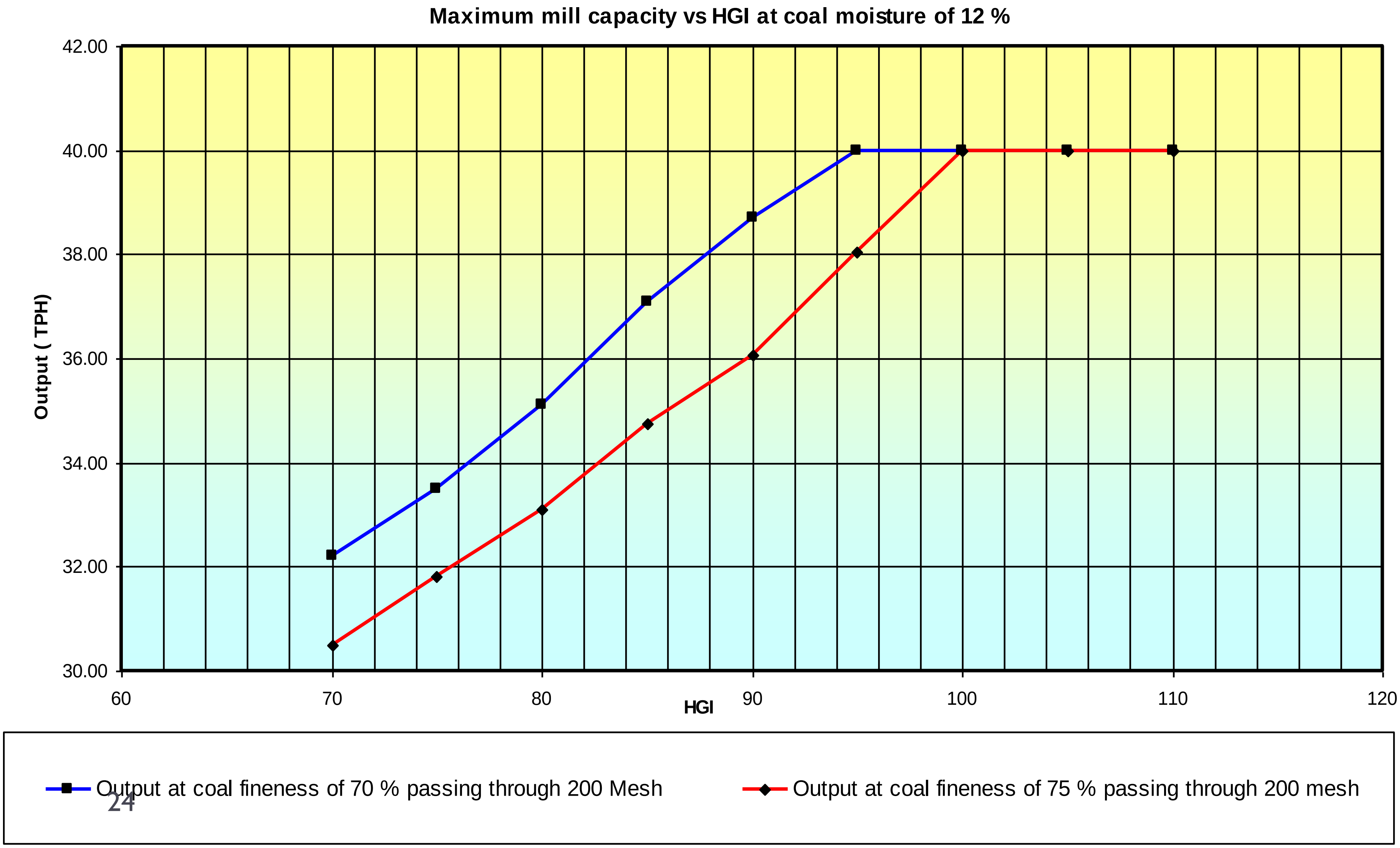


FIG. 1 Effect on pulveriser output of (a) Grindability of coal and (b) Fineness required

- Higher the HGI more is the capacity
- Normally mill capacity is indicated at 50/55 HGI.
- Actual Mill capacity varies with HGI

Effect of Grindability



Moisture in Coal

- Moisture: Inherent and surface
- Inherent moisture locked up within the structure
- Inherent moisture is constant for a particular seam
- Surface moisture varies
- Coal must be dried to remove the surface moisture totally before grinding
- Beside drying primary air also
  - Create circulation
  - Transport coal
  - Provide initial oxygen for combustion
- PA quantity is 15 to 28% of total air

Moisture in Coal

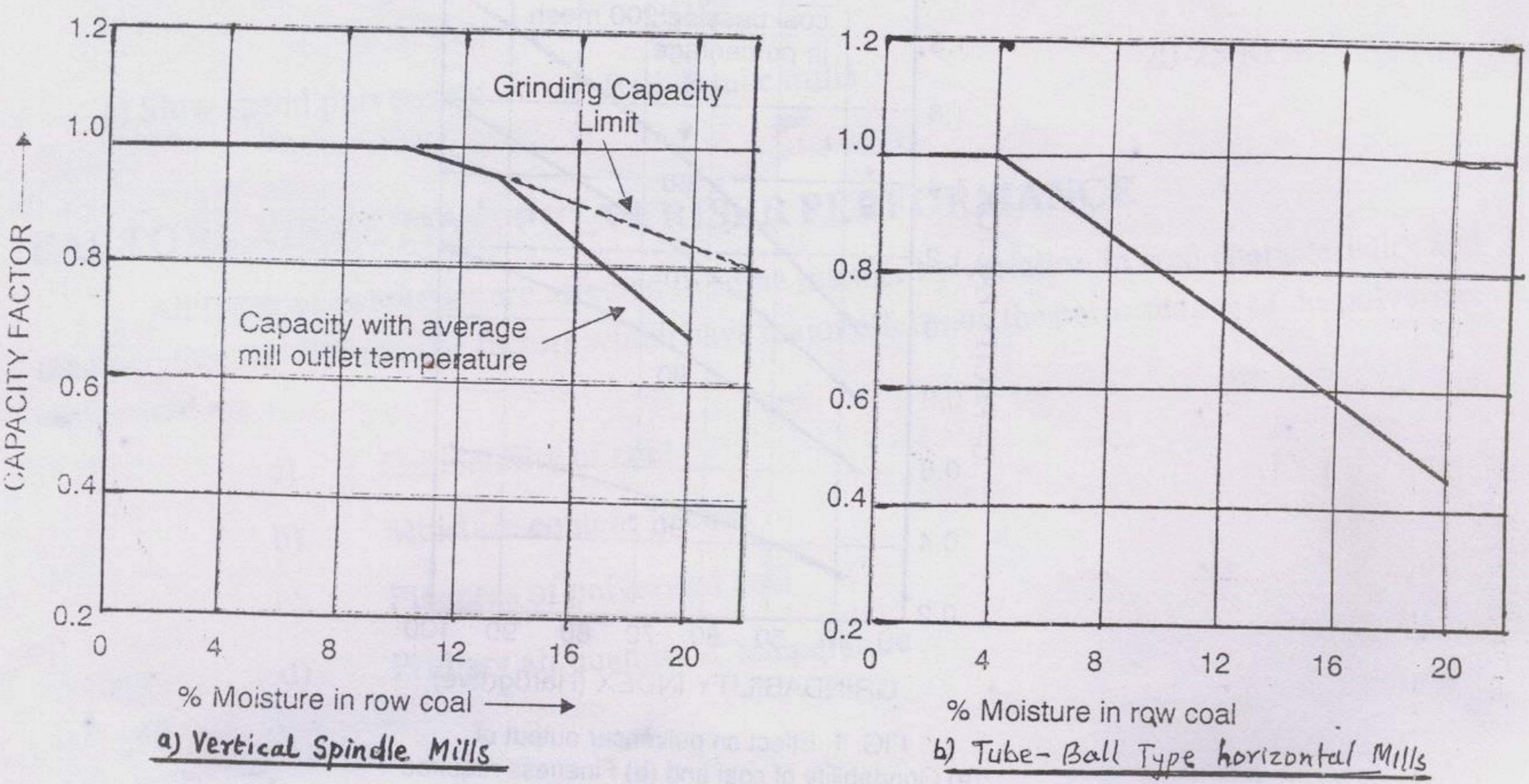
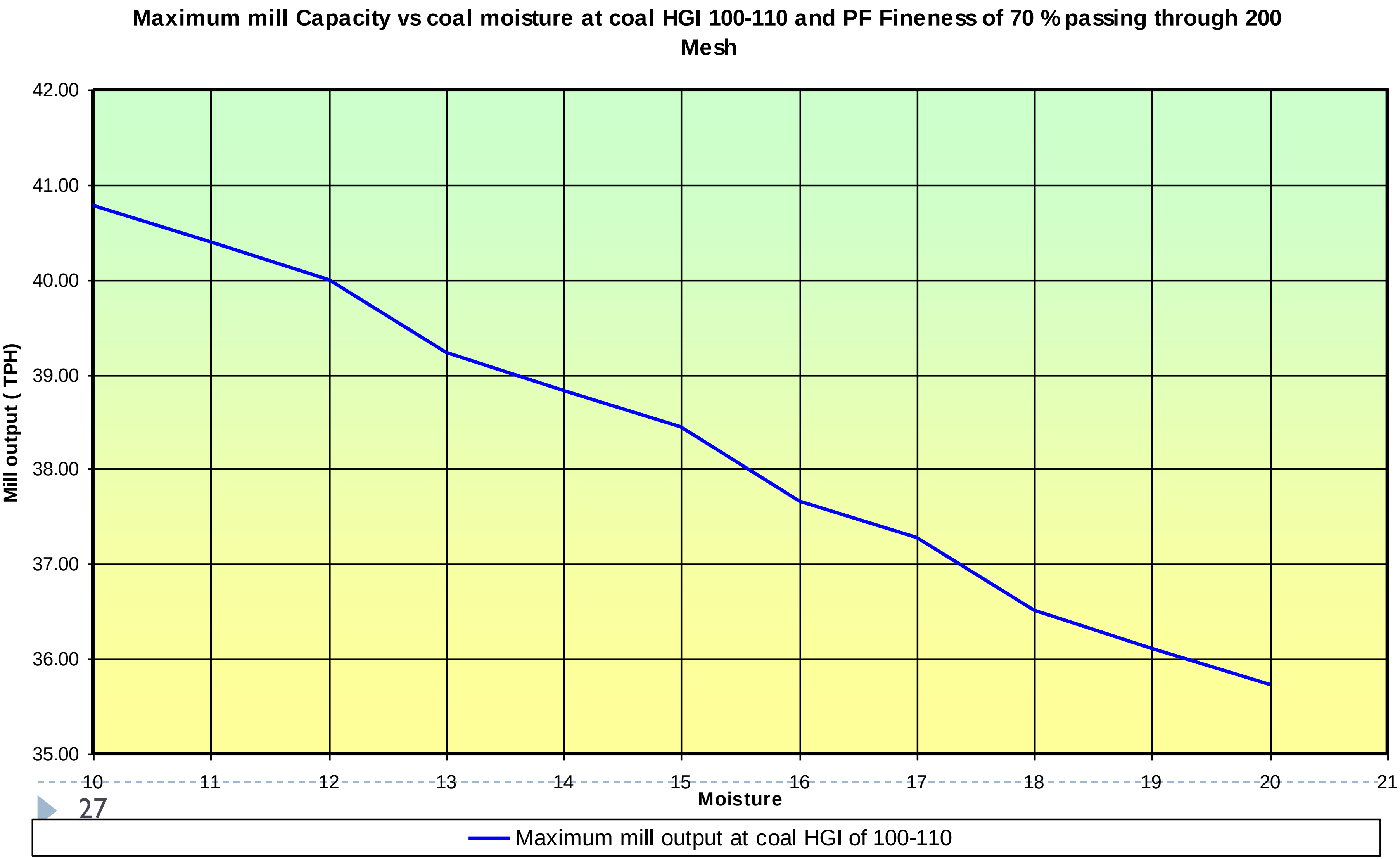


FIG 2(a) & 2(b) - Variation in mill output with total moisture content in raw coals.

Effect of Moisture



Temperature Of Coal –Air Mixture At Mill Outlet

- The temperature of pulverised coal and air mixture at pulveriser outlet should be maintained at least 15 ºC Above the dew point of air at pulveriser pressure to avoid condensation and consequent plugging of the coal pipes.
- The pulveriser mill outlet temperature should be maintained above 65 ºC.
- The higher limits are 90 ºC For high volatile (above 24%) coals and 110 ºC for low volatile coals (below20% VM)..

Effect of Fineness

- Fineness of pulverised coal
- More the fineness less is the capacity
- 70% through 200 mesh
- Number of opening per linear inch.
- 50 mesh sieve will have 2500 openings per square inch
- Volatile content below 16% would required higher degree of fineness i.E.75 to 80% through 200 mesh sieve, whereas the higher volatile coals (above 24%) will ignite and burn with ease with lower fineness of 60% through 200 mesh sieve.

Effect of Fineness

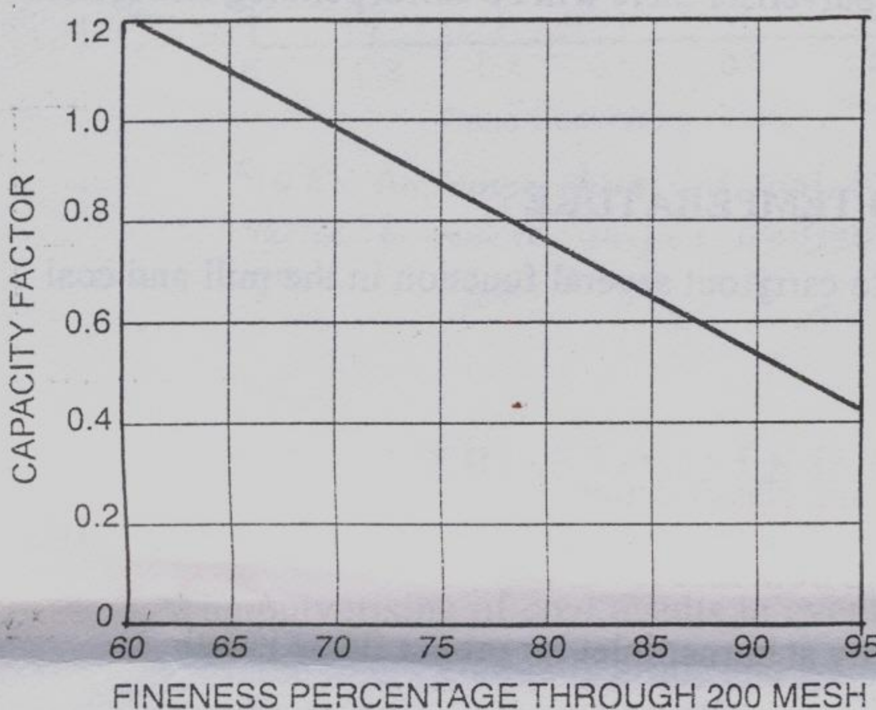


Fig. 4(a) Variation in mill output with fineness of mill product

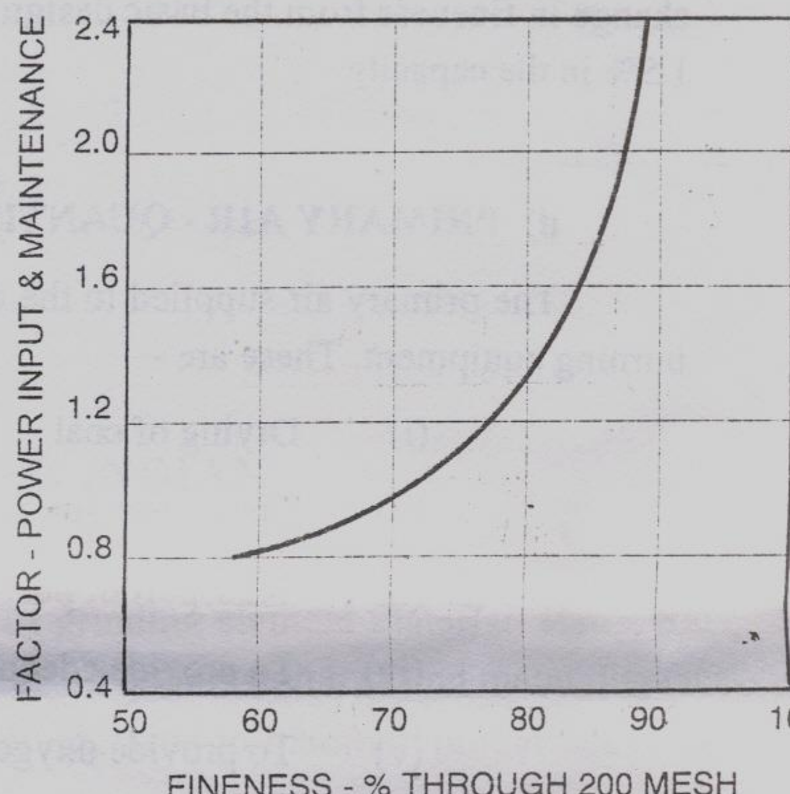
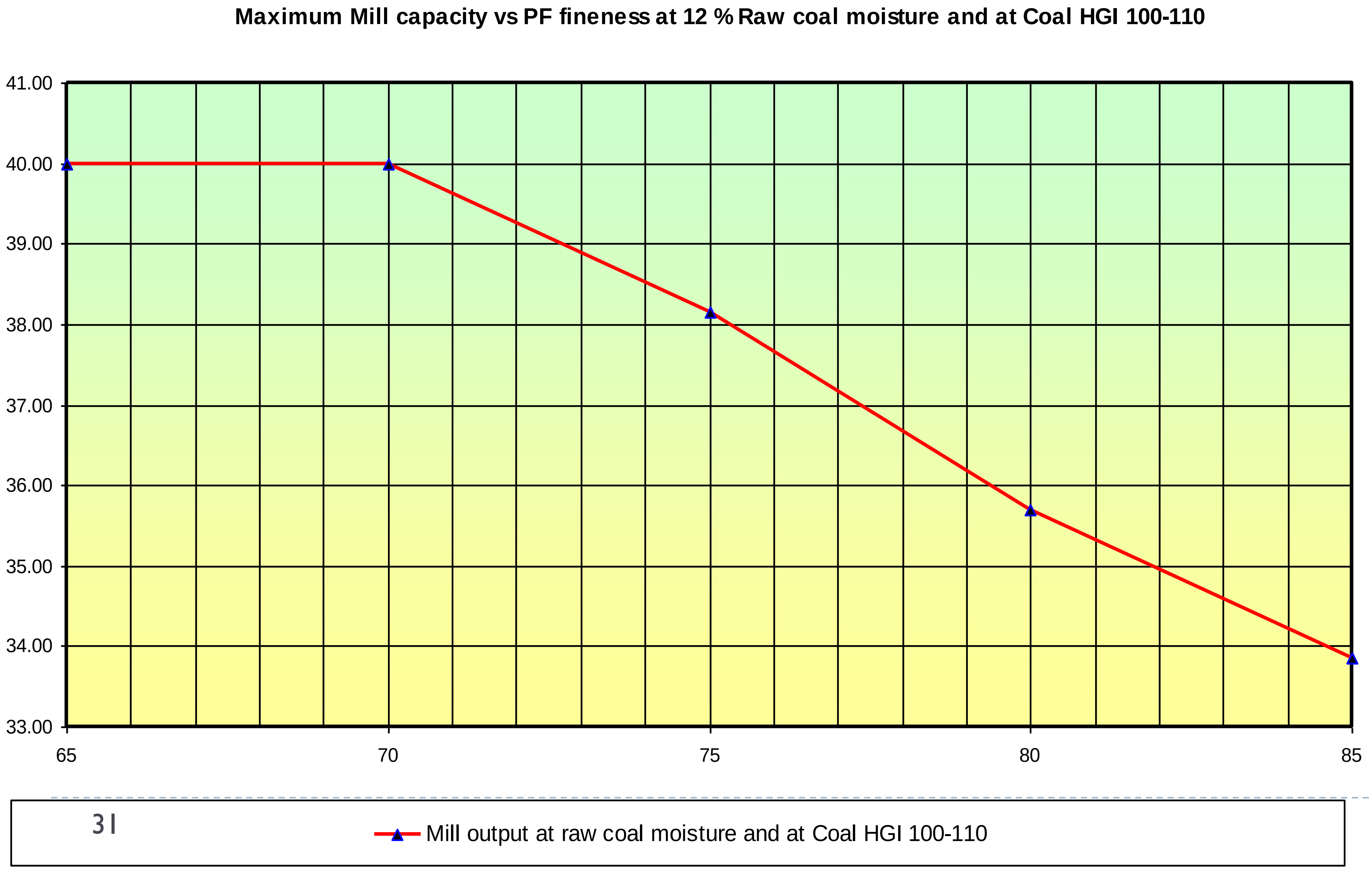


Fig. 4(b) Variation in power input and mill maintenance with fineness of mill product.

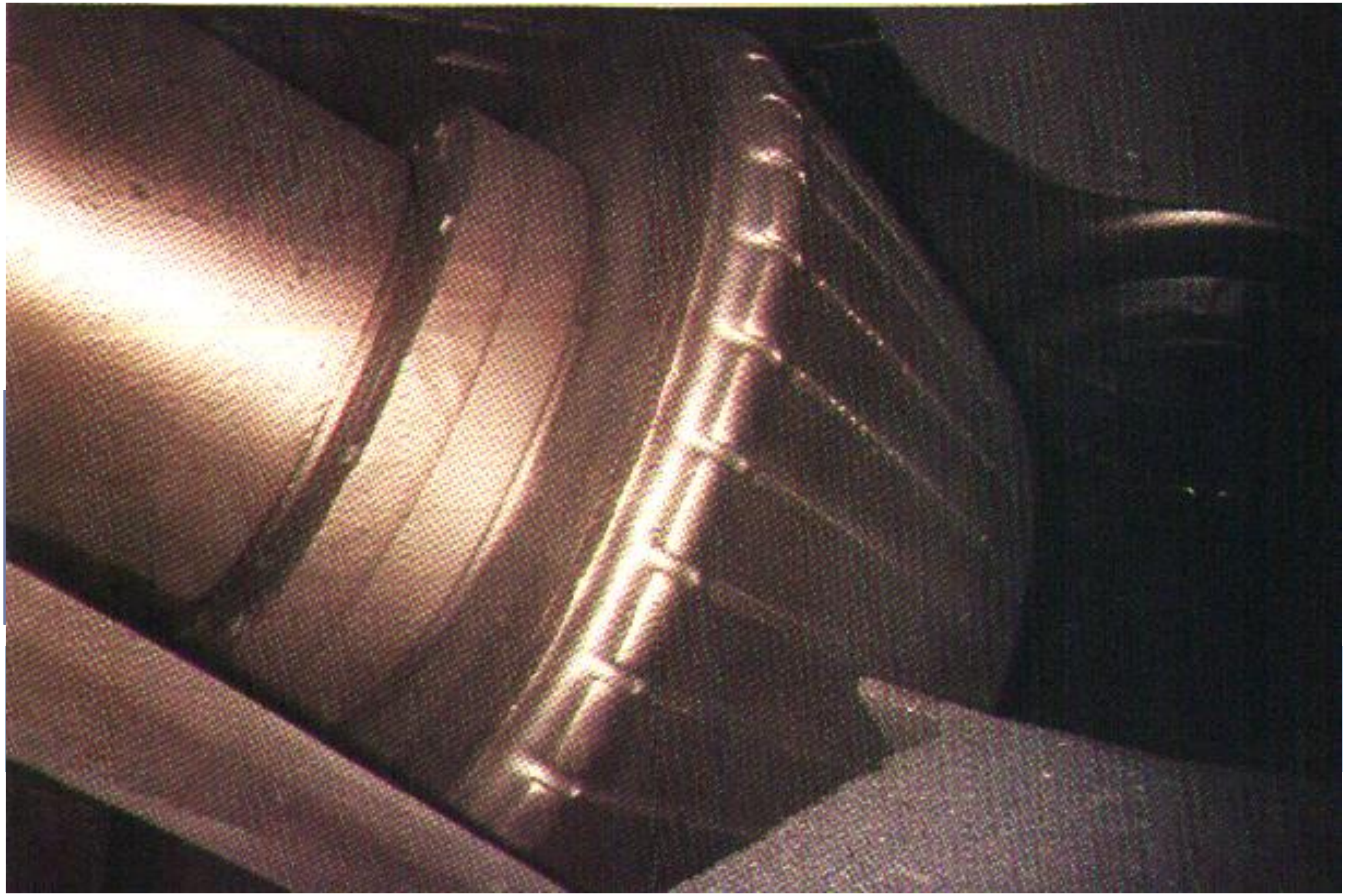
Effect of fineness



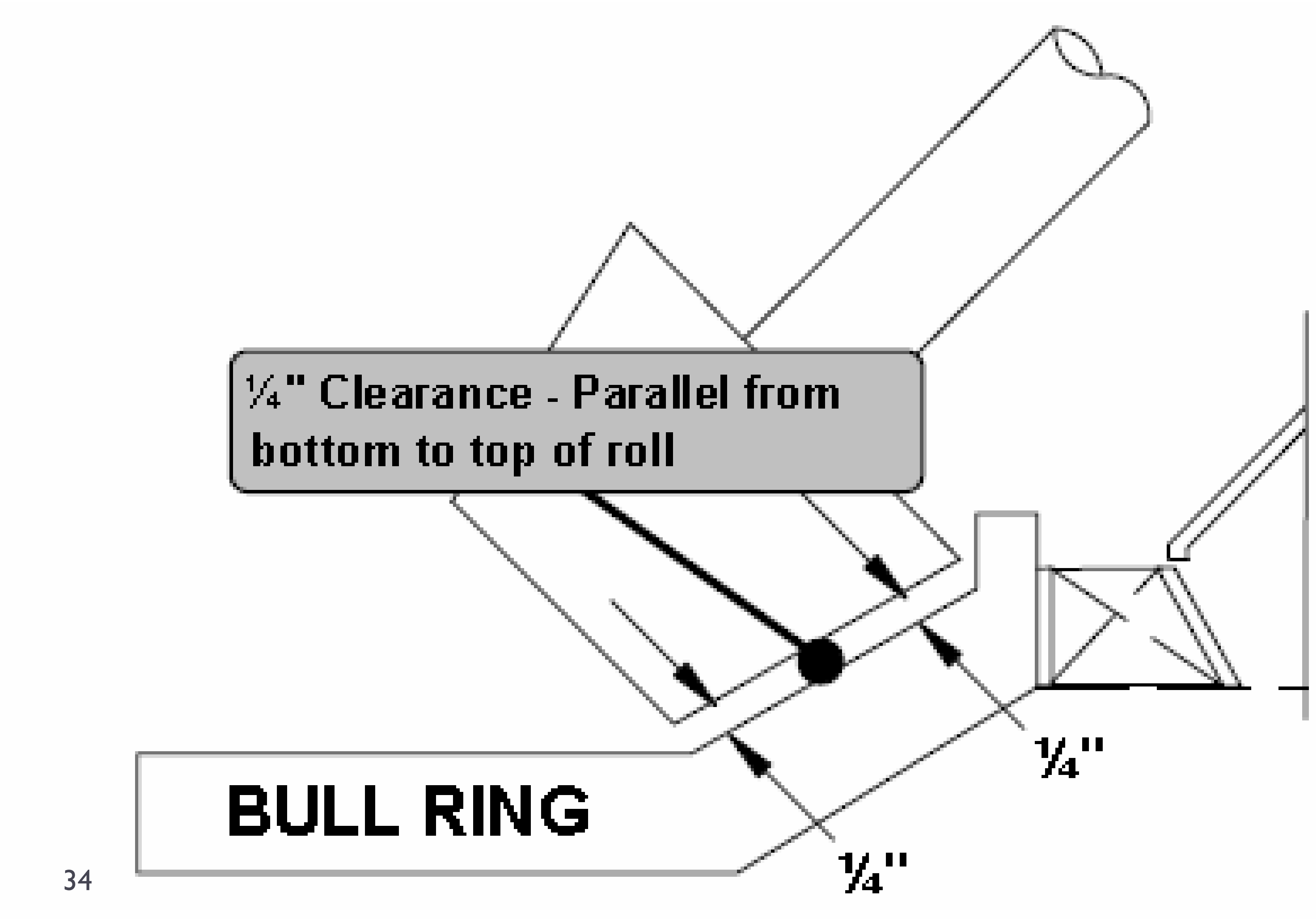
Fineness Requirement

Sizing Range of Coals for PC Firing[80]

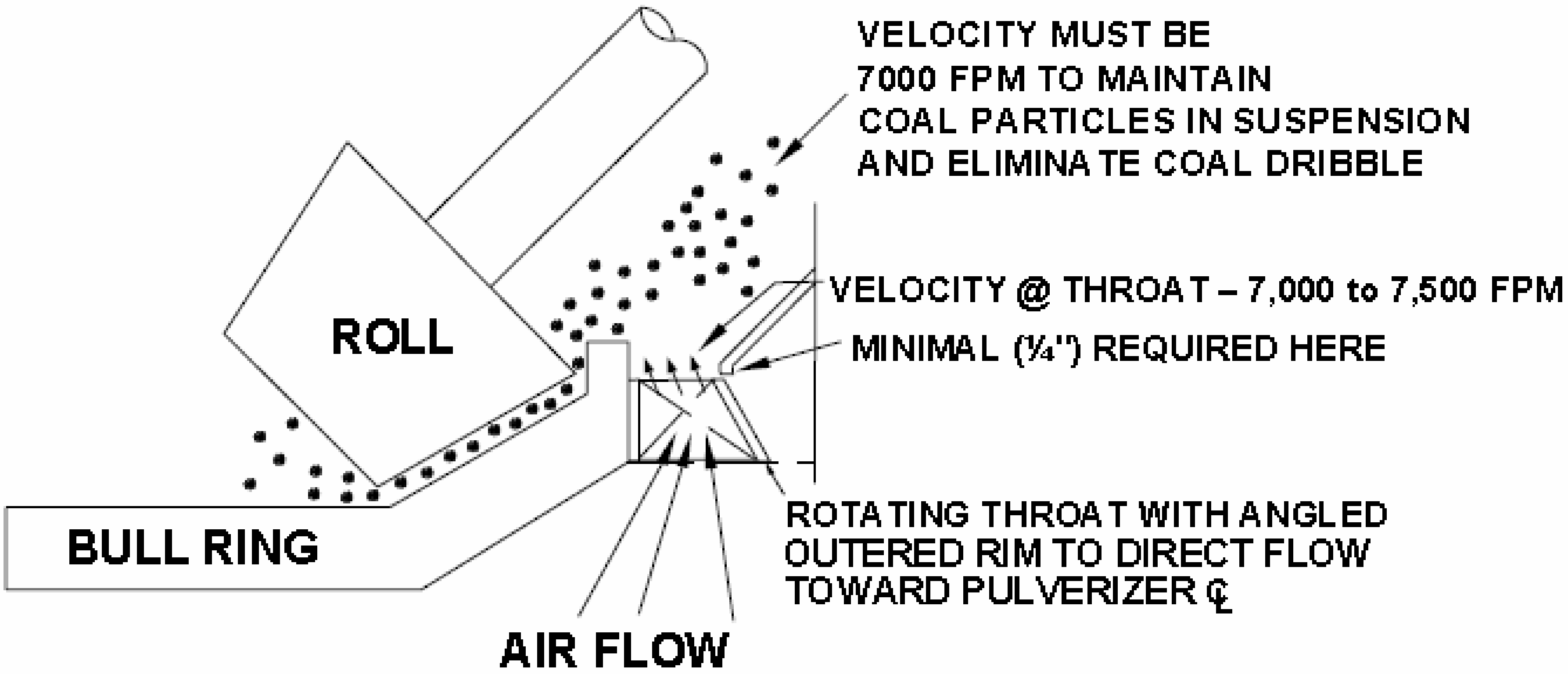
Coal rank	Passing 200 mesh, wt %	Retained on 50 mesh, wt %
Subbituminous C coal and lignite	60-70	2.0
High-volatile bituminous C, subbituminous A, B	65-72	2.0
Low- and medium-volatile bituminous C, high-volatile bituminous A and B	70-75	2.0

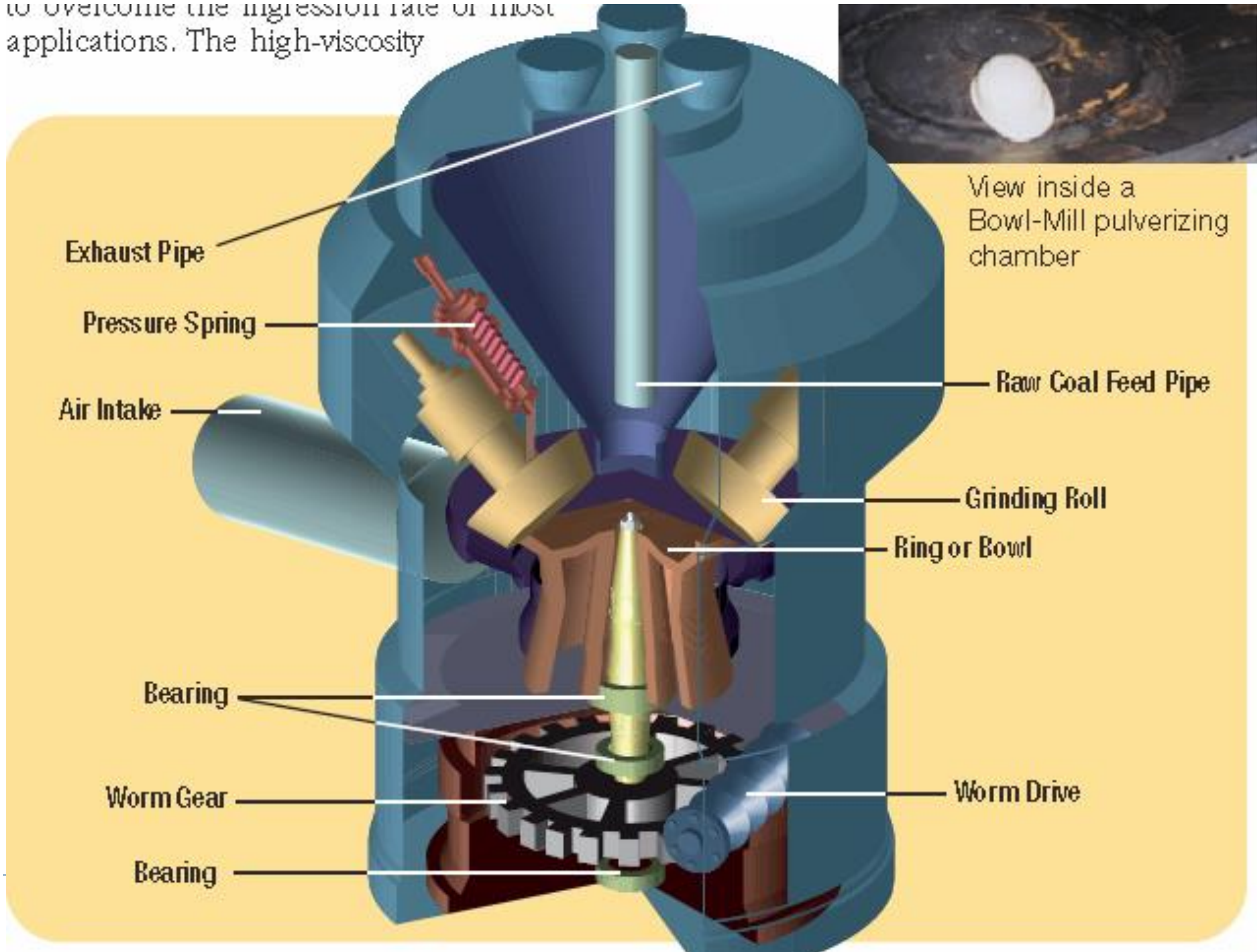


Roller Setting

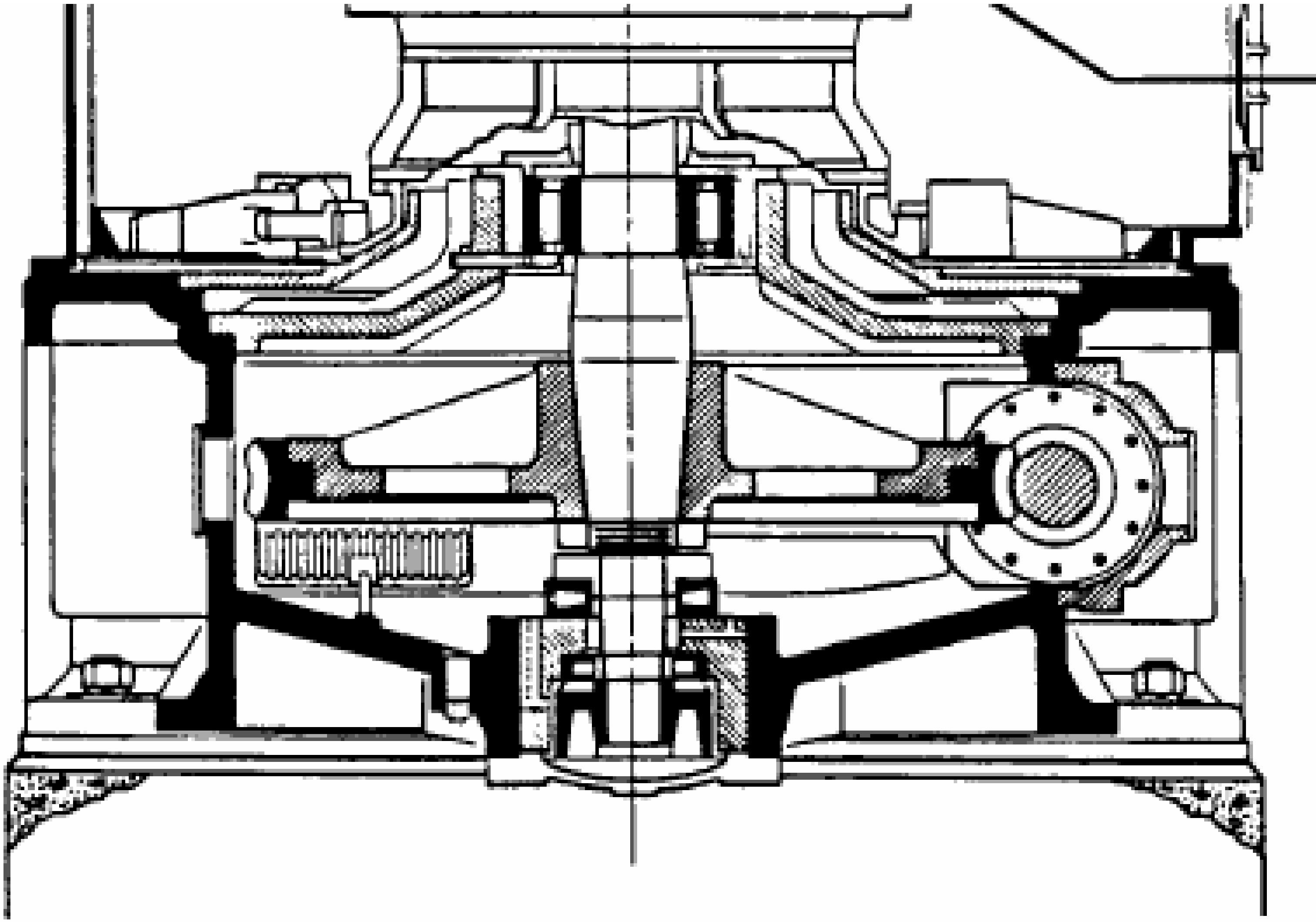


Throat Velocity

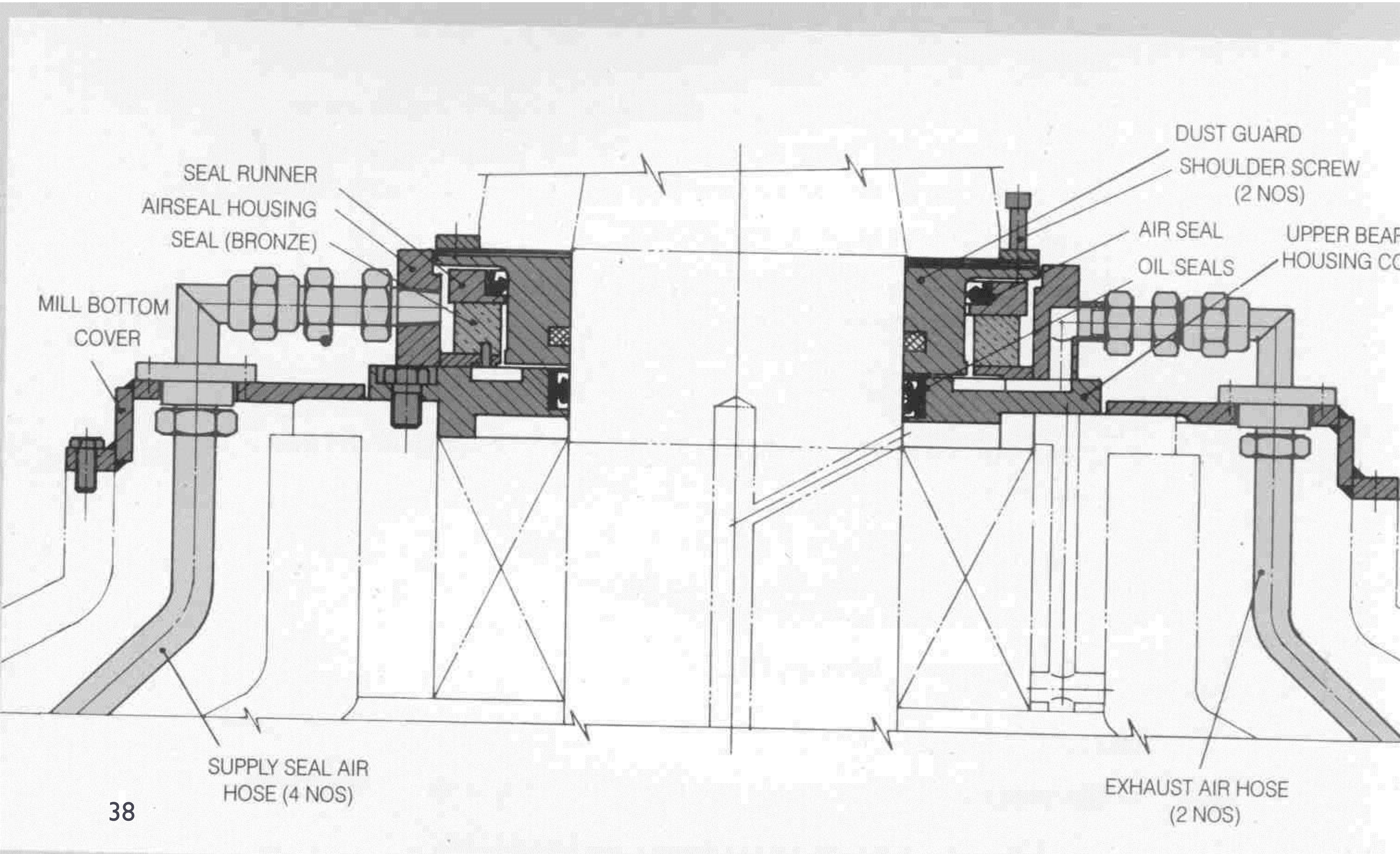



applications. The high-viscosity
View inside a
Bowl-Mill pulverizing
chamber
Exhaust Pipe
Pressure Spring
Air Intake
Raw Coal Feed Pipe
Grinding Roll
Ring or Bowl
Bearing
Worm Gear
Worm Drive
Bearing

Mill Gear Box



Mechanical face Seal



Various modifications

- Split type seals in journal and vertical Shaft
- Spring loaded mechanical face seal
- Ceramic tiles at separator body
- Tall separator top

Tall Separator Top

Tall Separator Top

Annexure – 4

SEPARATOR TOP (TALL TYPE)

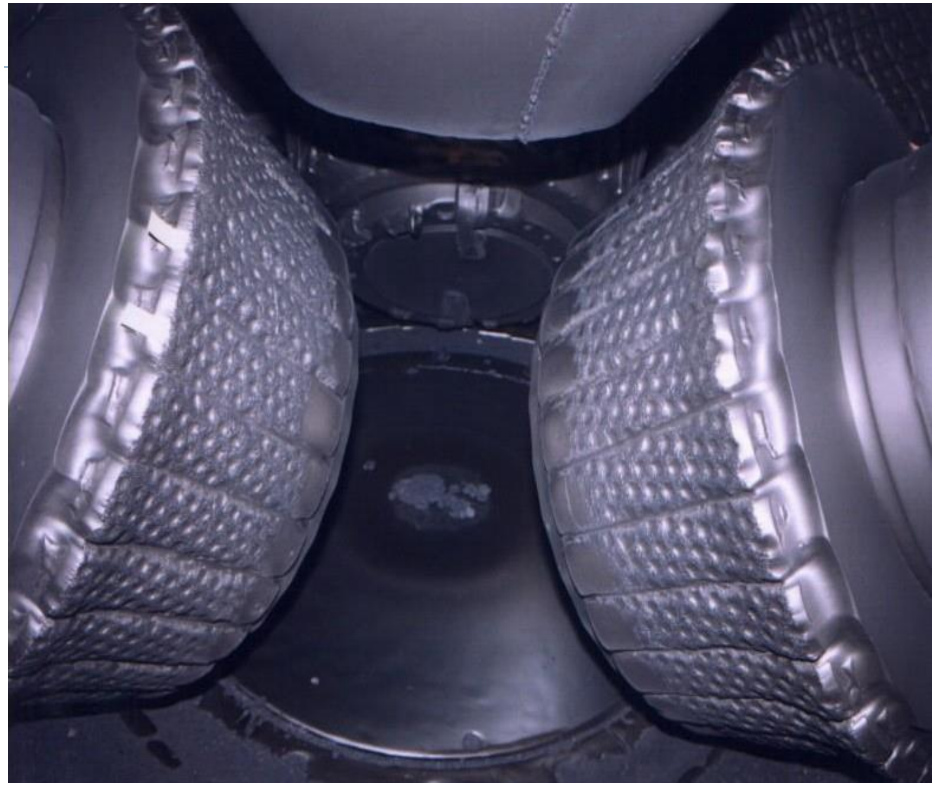
Split type seal

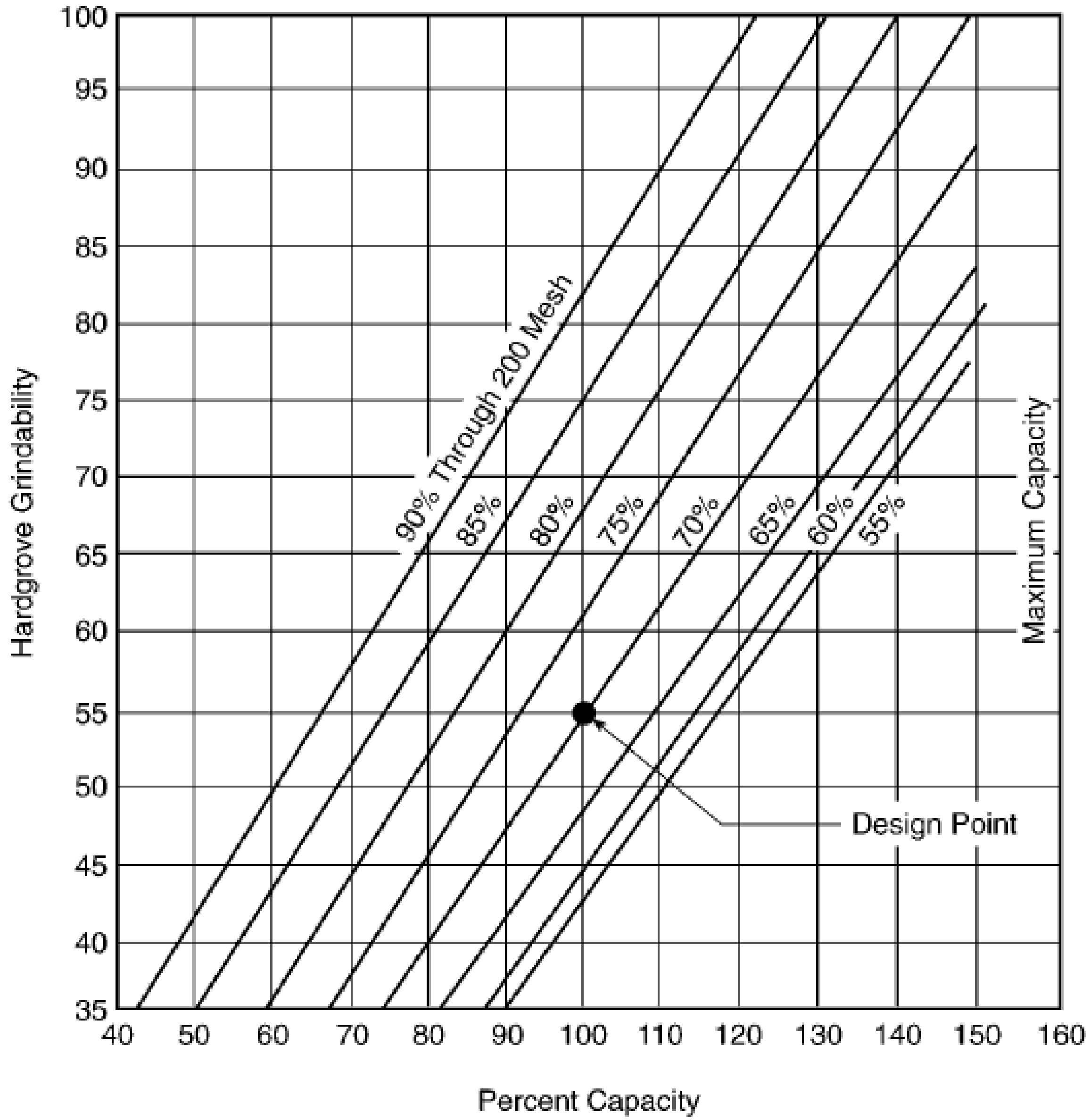
Effect Of Mill Internals On Mill Fineness

- Classifier blades opening
- Holes in classifier blades
- Holes in innercone
- Improper gap between inverted cone and inner cone
- Spring tension
- Clearance between grinding roll & brs
- Wear out of grinding elements

Factors Affecting Mill Performance

- HGI
- Fineness
- Moisture
- Size of raw coal
- Mill wear (YGP)
- Maintenance practices




Hardgrove Grindability
Percent Capacity
Maximum Capacity
90% Through 200 Mesh
85%
80%
75%
70%
65%
60%
55%
Design Point
100
95
90
85
80
75
70
65
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50
45
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35
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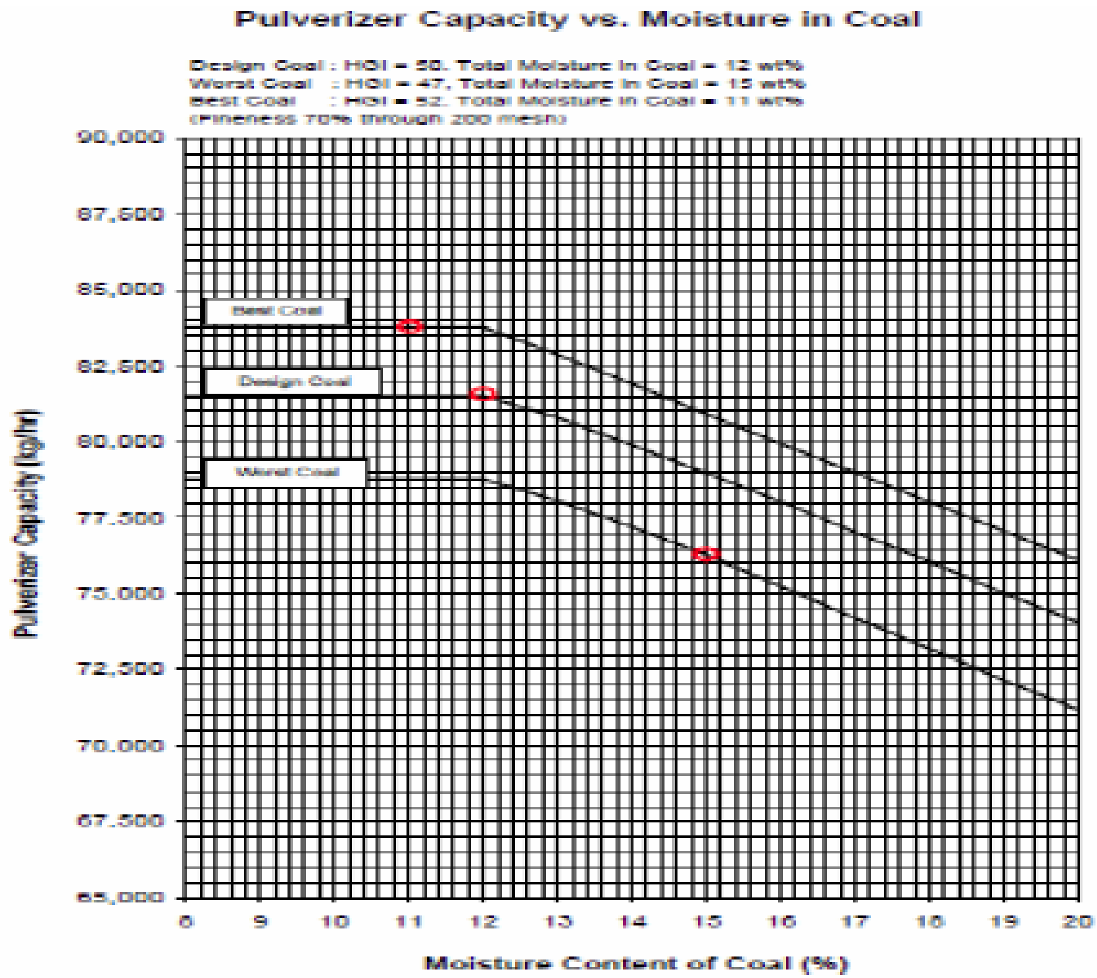
140
150
160



Pulverizer Capacity vs. Moisture in Coal
Design Coal : HGI = 50, Total Moisture in Coal = 12 wt%
Worst Coal : HGI = 47, Total Moisture in Coal = 15 wt%
Best Coal : HGI = 52, Total Moisture in Coal = 11 wt%
(Fineness 70% through 200 mesh)
90,000
87,500
85,000
82,500
80,000
77,500
75,000
72,500
70,000
67,500
65,000
Best Coal
Design Coal
Worst Coal
Pulverizer Capacity (kg/hr)
8
9
10
11
12
13
14
15
16
17
18
19
20
Moisture Content of Coal (%)

Coal particle size distribution

- If 1-2% is +50 in BS mesh sieve (300 μm), most of this coarse coal will not burn and end up in C in BA
  - It also frequently causes slagging around the burners
- If -200 mesh (75 μm) fineness is poor, results in high C in FA
- If the coal is not properly ground, the distribution to the burners may not be even
  - Resulting in air-fuel imbalances at one or more burners

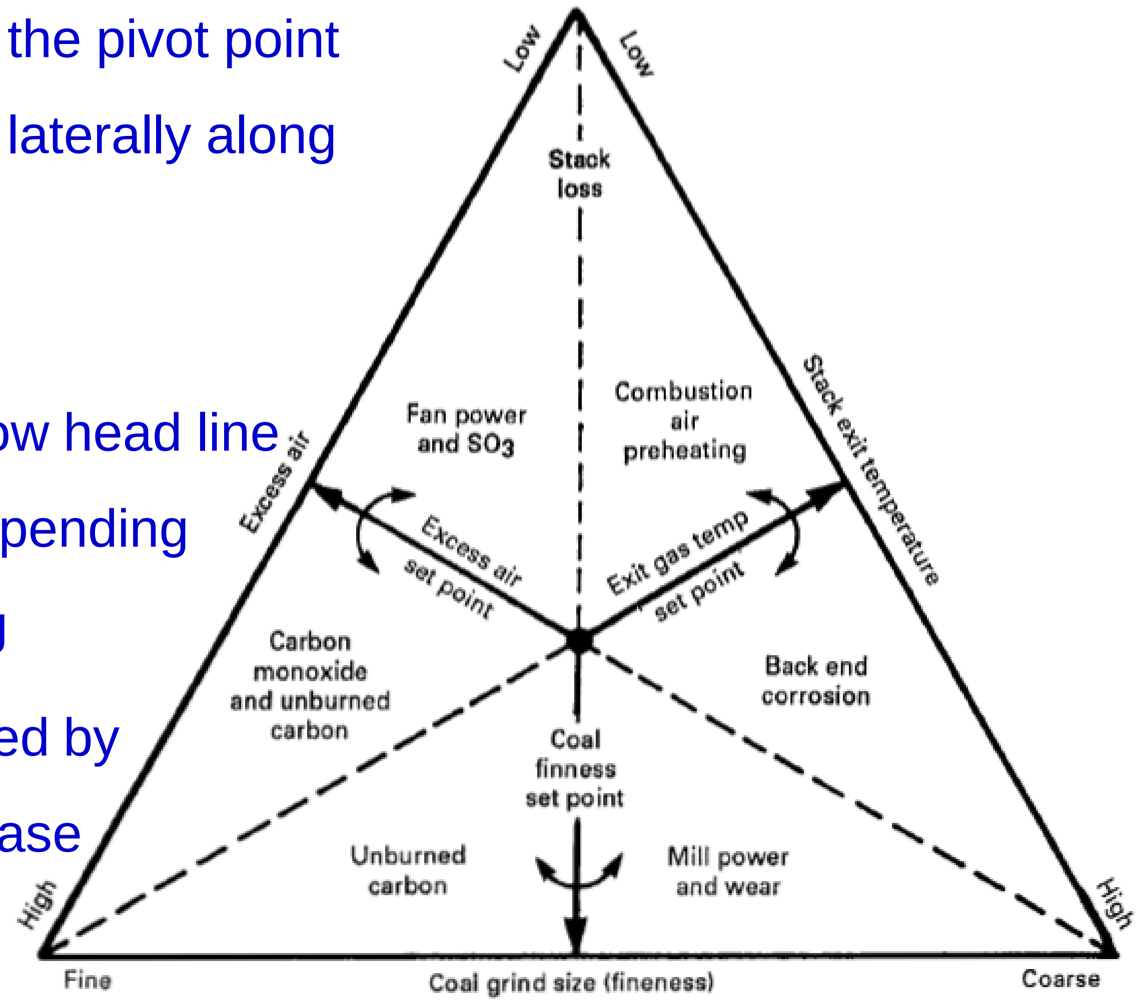
Fuel line balance

- Mill discharge pipes offer different resistances to the flows due to unequal lengths and different geometry/layouts.
- Fixed orifices are put in shorter pipes to balance velocities, dirty air / PF flows.
  - The sizes of the orifices are normally specified by equip. supplier
  - Variable/adjustable orifices
- Dirty air flow distribution should be within +/- 5%
- Coal distribution within +/- 10% of the mean value

Interrelationship of parameters

- Each line can rotate about the pivot point
- The arrow head can move laterally along the line it touches

- The area swept by the arrow head line increases or decreases depending upon the direction of swing
- The parameters represented by the area increase or decrease as the area changes



Combustible in Ash Loss

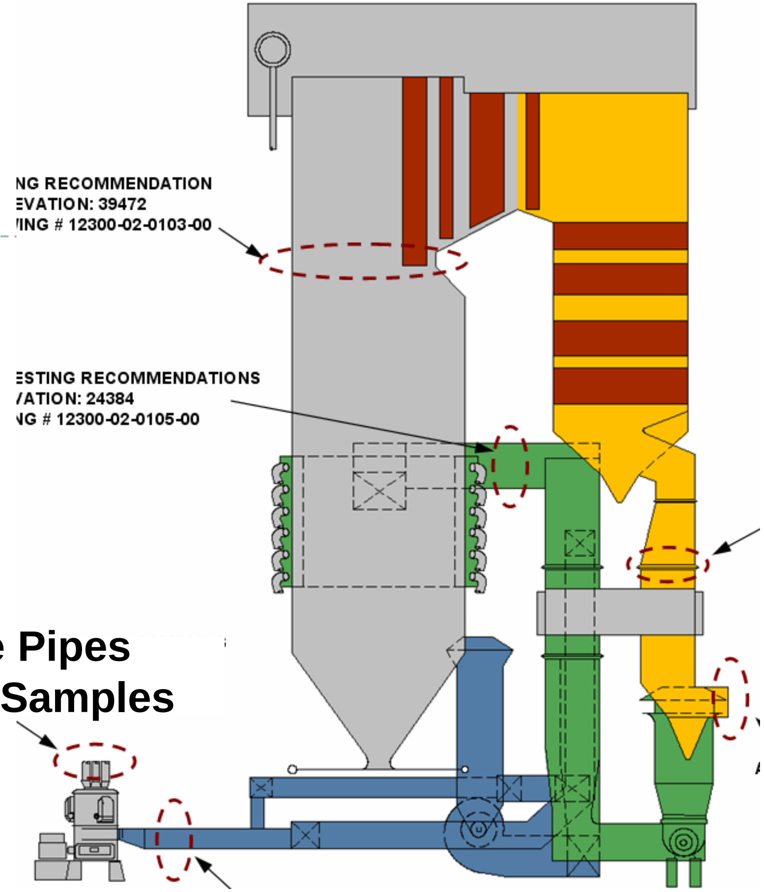
- Measure of effectiveness of Combustion process and Mill performance
- Loss in kJ/kg of fuel: $\frac{cA}{100} * 33820$
- c= % of carbon in ash
- A= Mass of ash kg/kg of fuel
- Carbon burnt to CO_2 =33820 kJ/kg (8077 kcal/kg)
- Compute Boiler efficiency loss % due to c in Ash

The Diagnostic Tests

- Representative & accurate performance data
- RCA , Identify reasons for inefficiency
- Verify online FB

- **Dirty Airflow Tests**
- **Iso-kinetic Coal Sampling**
- **PA Flow Calibration**
- **Clean Airflow Tests**
- HVS
- Furnace Exit HVT
- Air In-Leakage survey
- Insulation survey
- Furnace temperature survey
- Boiler Efficiency Tests
- AH Performance Tests

➢ **Boiler Tuning & Optimization**



- Turbine Cycle Heat Rate Test
- Turbine Cylinder Efficiency Test
- Condenser Performance Test
- Condenser Air in-leak Test
- Heater Performance Test

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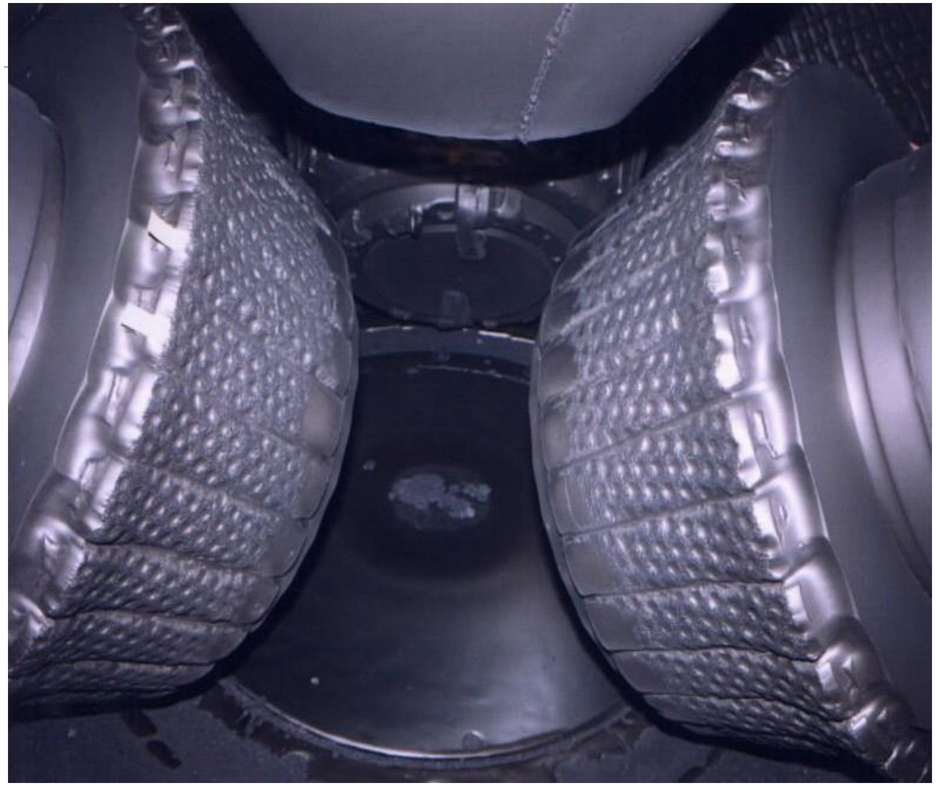

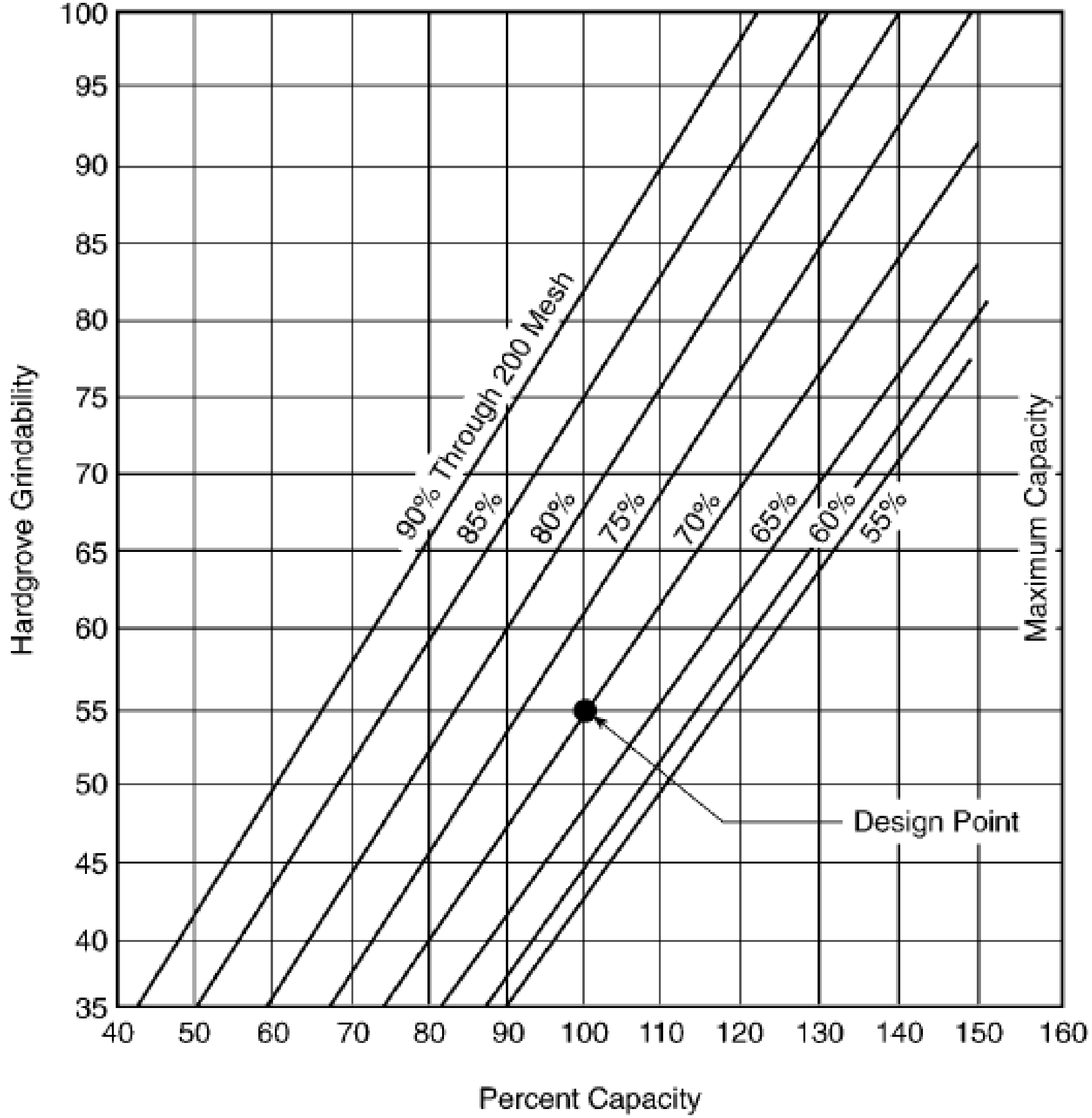

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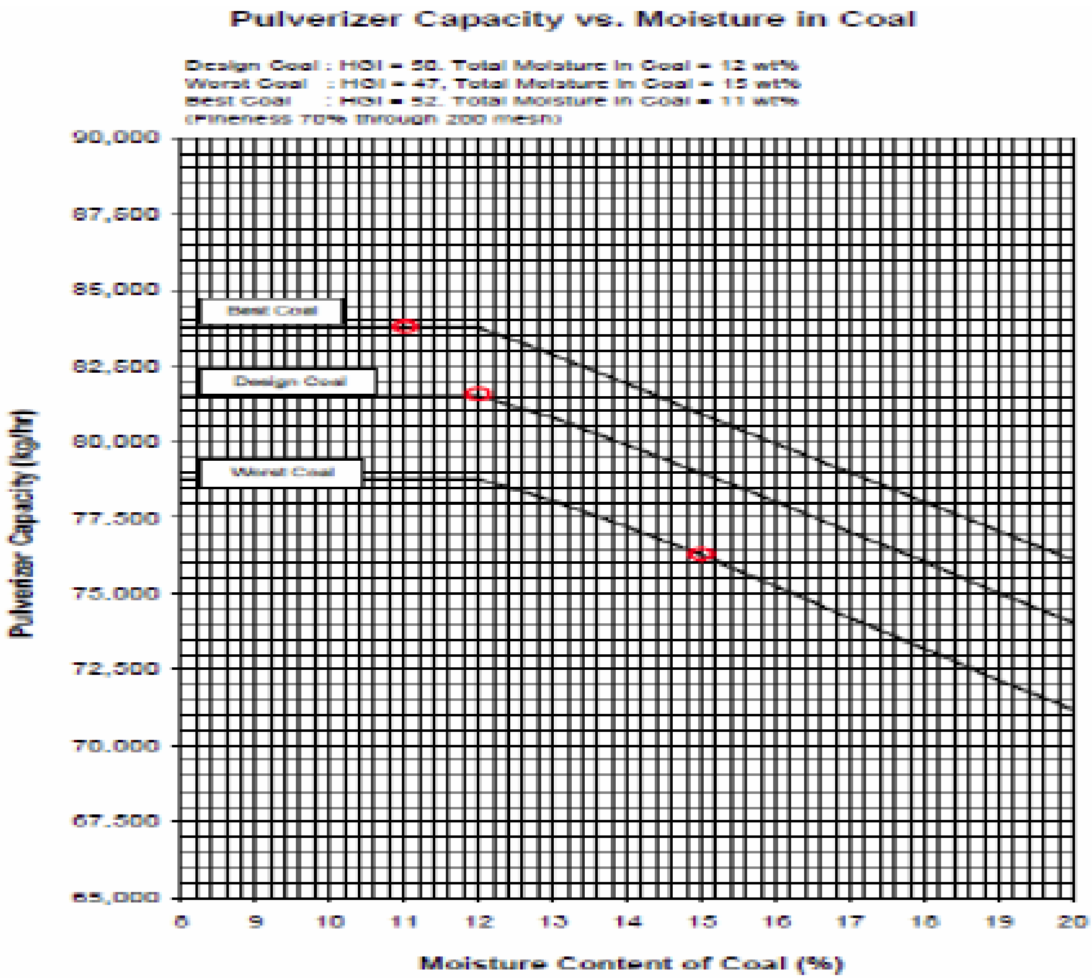
Design Point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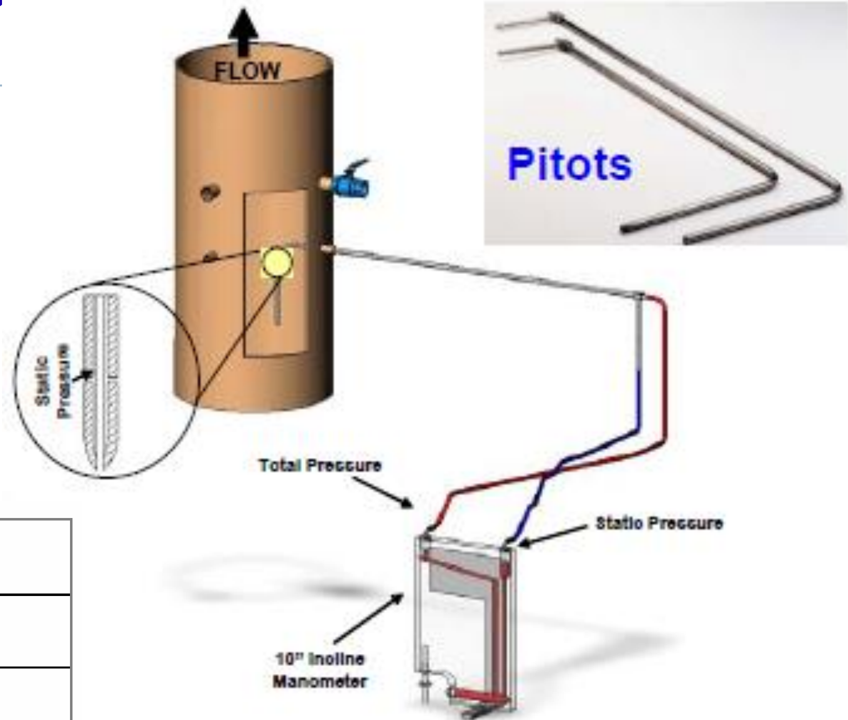
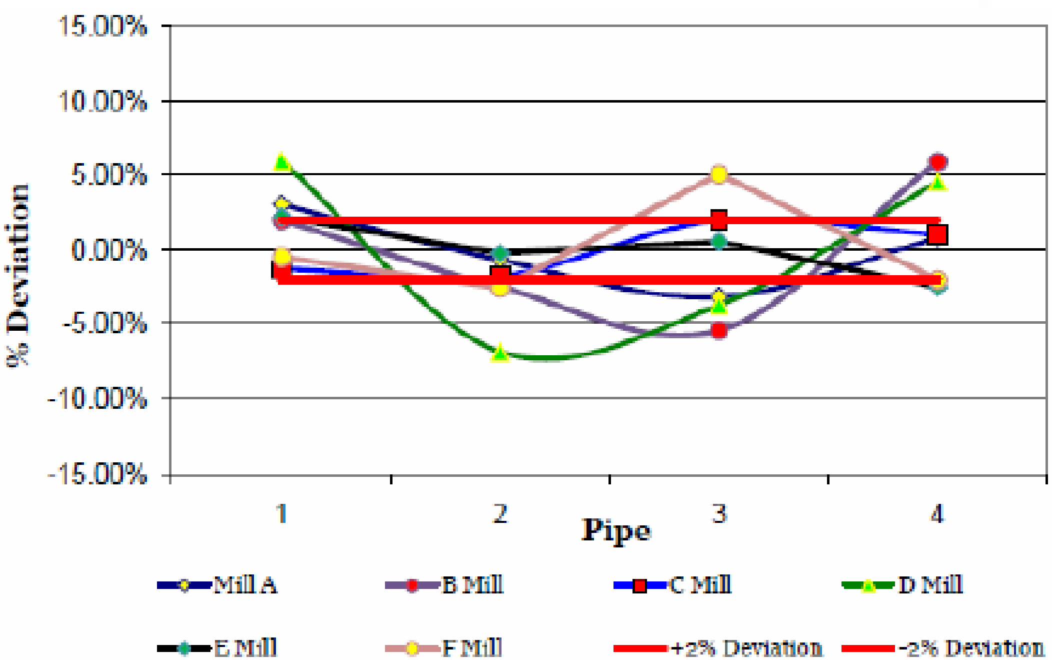
- Coal distribution within +/- 10% of the mean value

Clean Air Flow Test

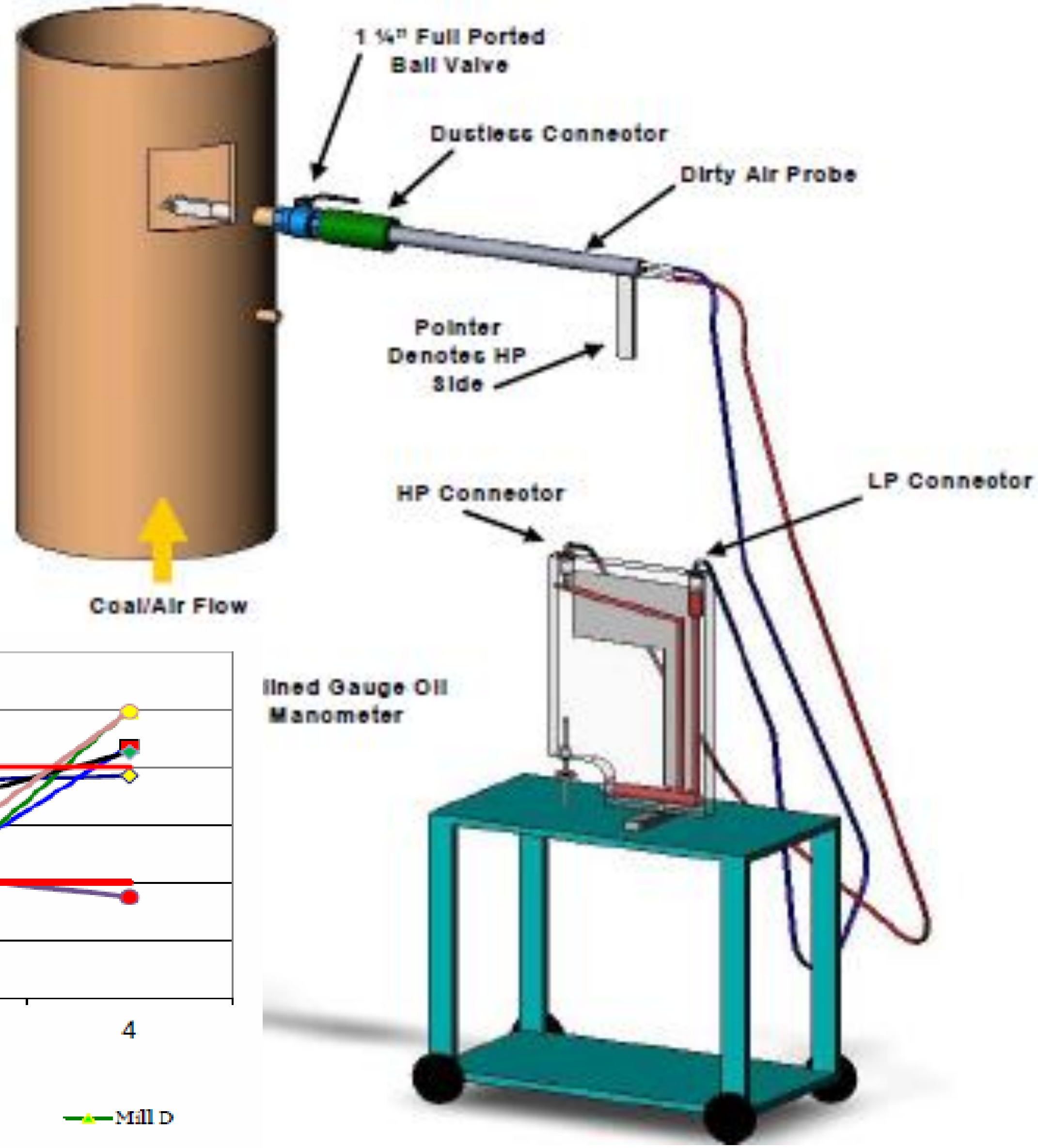
- Clean Air flowing through the fuel lines at normal operating temp and pres.
- Indicative of the transport energy
- Clean air vel. should be within +/- 2% of the mean.

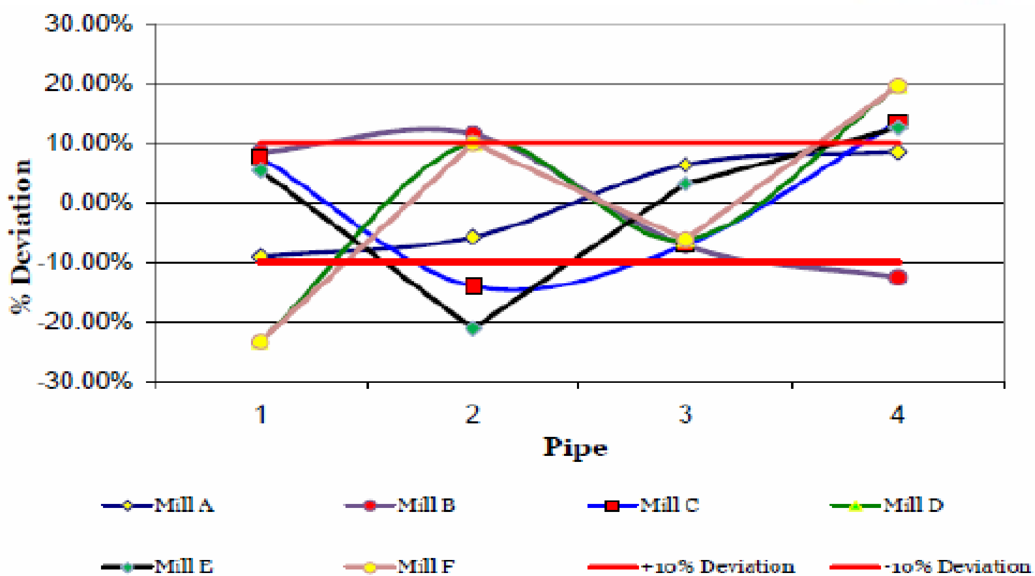




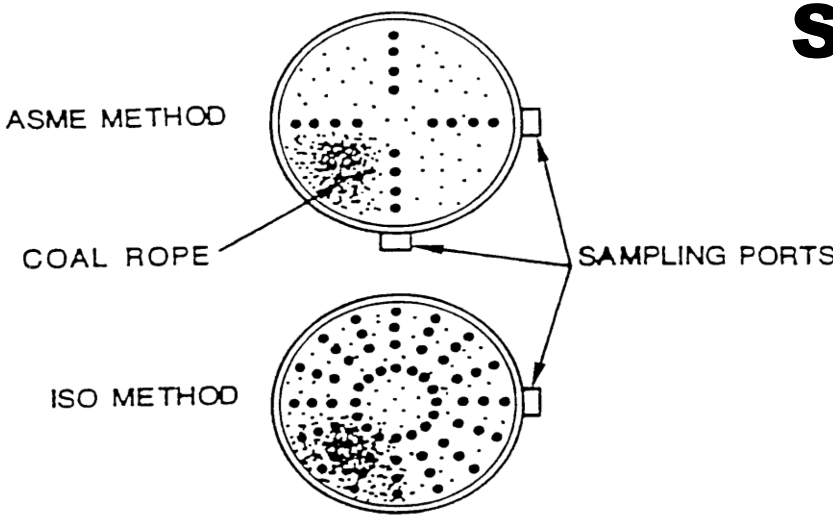
Dirty Air Flow Test

- PF air mix flowing thro fuel lines with mill in service
- To determine coal & air flow in each line
- Dirty air vel. should be within +/- 5% of the mean





Sampling grids
ASME PTC 4.2



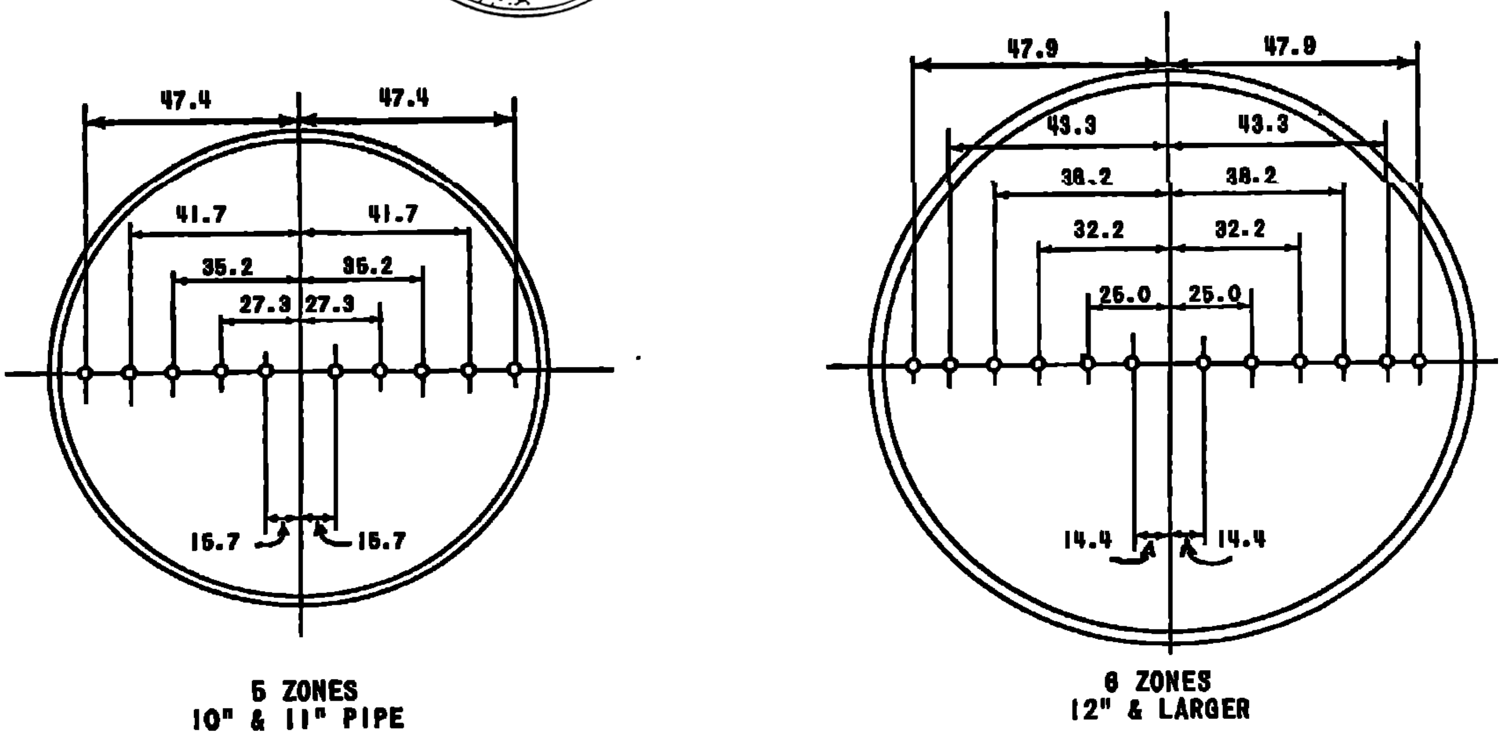


FIG. 7 SAMPLING DIRECT-FIRED PULVERIZED COAL-SAMPLING STATIONS
DIMENSIONS ARE "PERCENT OF PIPE DIA."

Dirty Pitot Survey - Summary Data (Mill X)

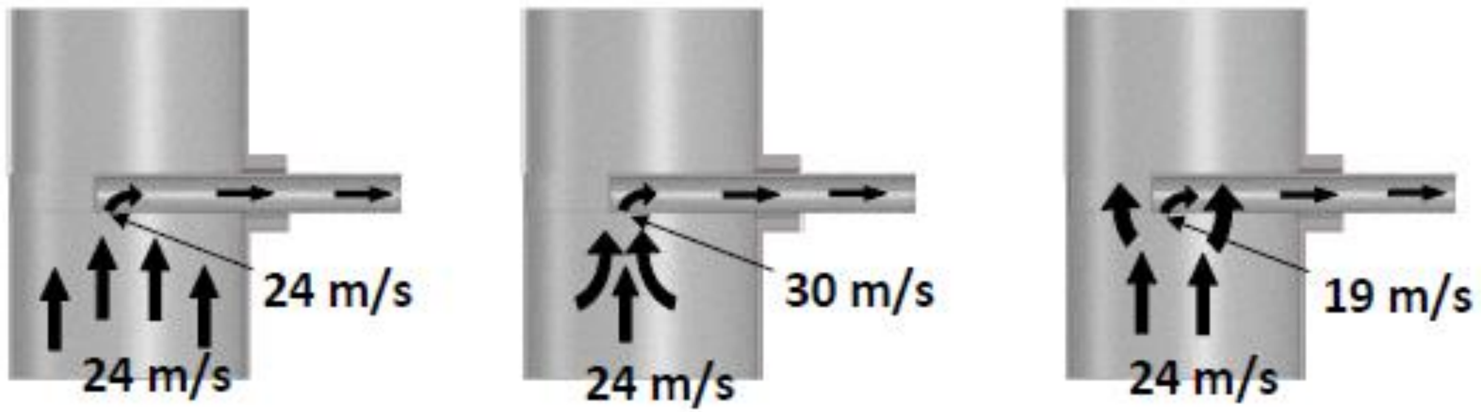
	UCB	Measured
Air Flow T/hr	40	43.6
Mill Outlet Temp C	65	54.8
Coal Flow T/hr	-	26.2

Description	Corner					
	1	2	3	4	Mean	Desired
Velocity m/s	24.3	22.9	16.0	17.4	20.2	> 18 m/sec
Air Flow T/hr	13.1	12.4	8.7	9.4	10.9	----
Dev. From Mean %	20.2	13.8	-20.2	-13.8	---	< +/- 5%
Mill Out Temp ^{o}C	56.0	55.0	53.0	55.0	54.8	~ 85^{o}C
Coal Flow T/hr	7.9	5.8	5.6	6.9	6.6	< +/- 10%
A/F Ratio	1.7	2.1	1.0	1.4	1.6	1.8 to 2.5

- Operating PA flow is lower by almost 4 - 5 T/h than design
- Mill Outlet temperature is low in all the pipes.
- Low mill outlet temperature coupled with low PA flow could be the reason for the choking observed in Pipes 3 & 4.

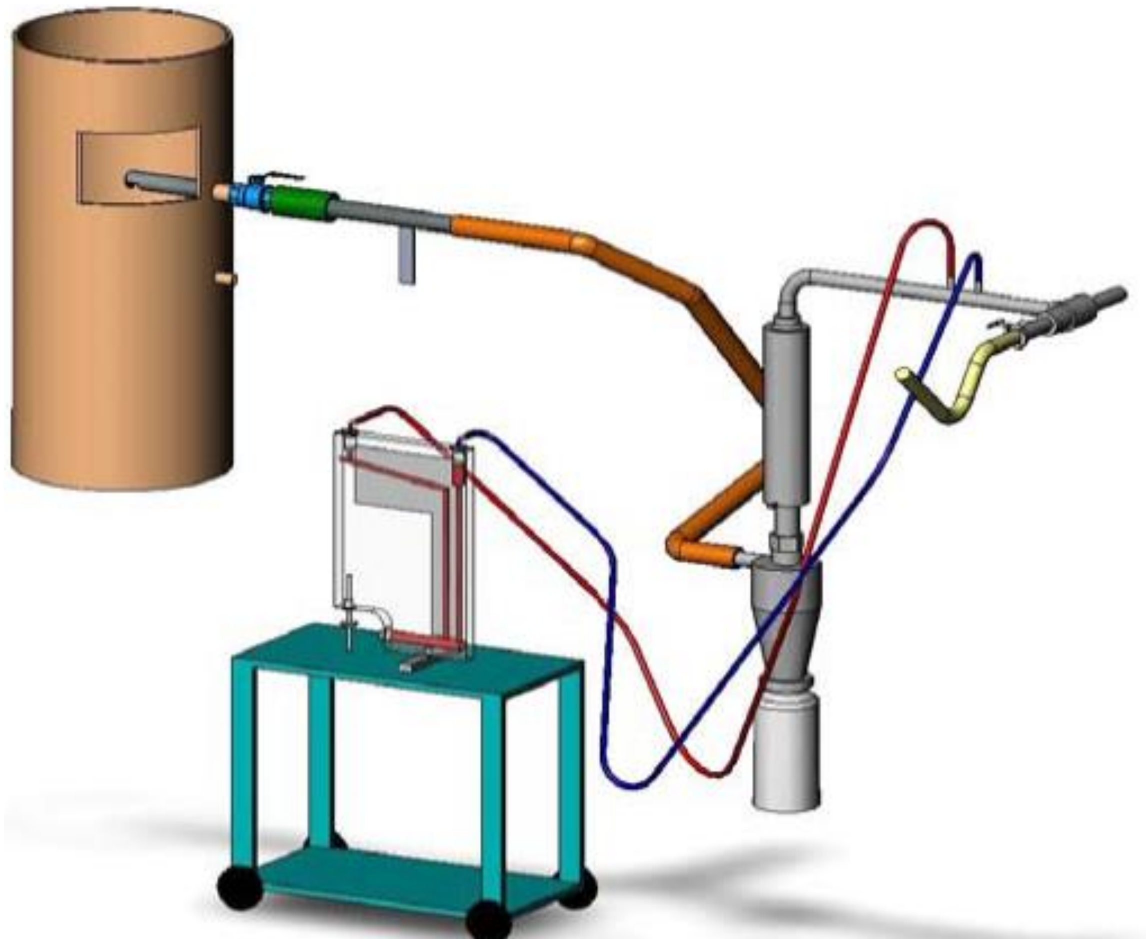
Iso-kinetic PF sampling

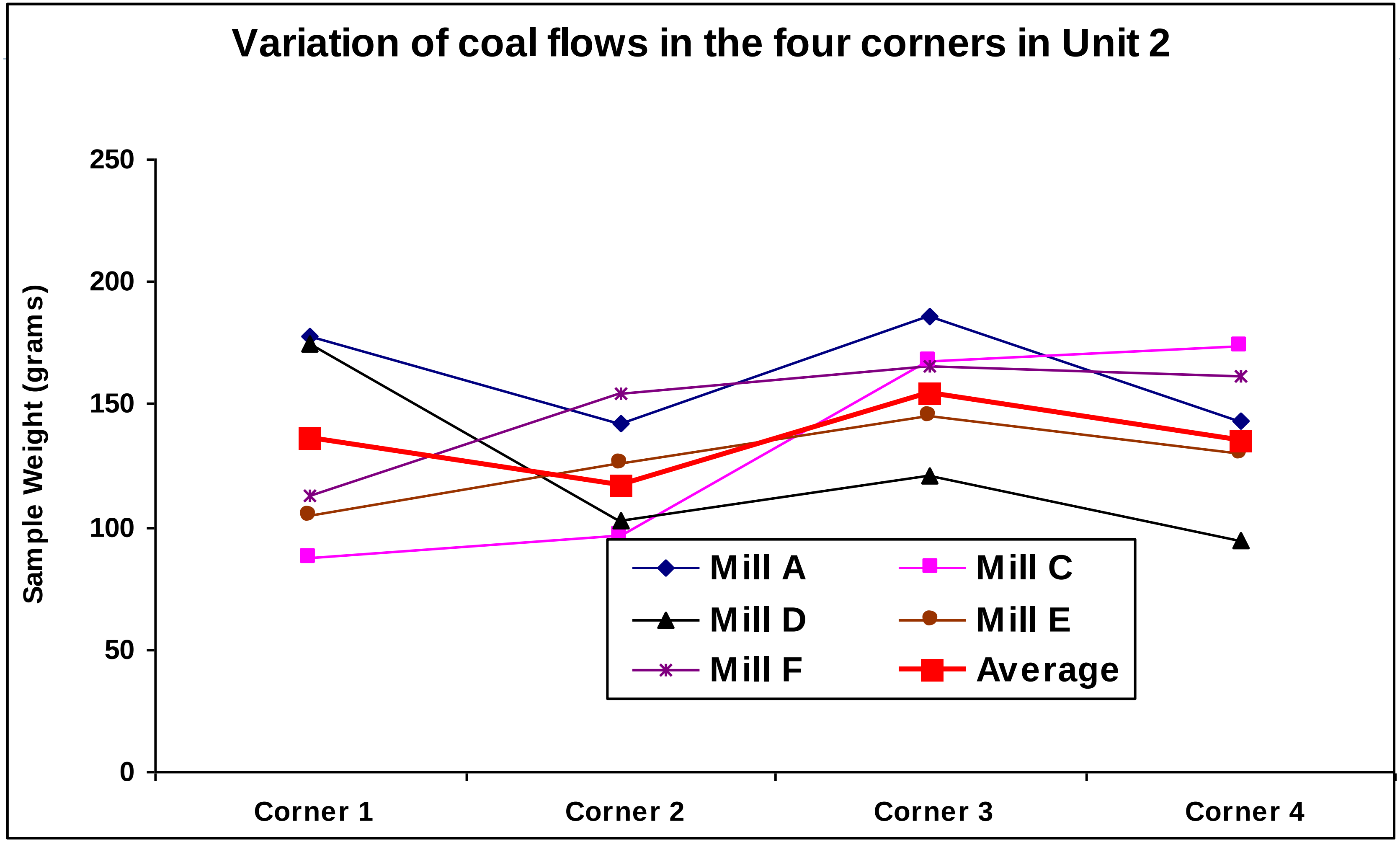
The velocity of dirty air entering the collection nozzle is equal to the velocity of the flow in the fuel line



More fines are drawn to the sampler

Allow fine particles to escape

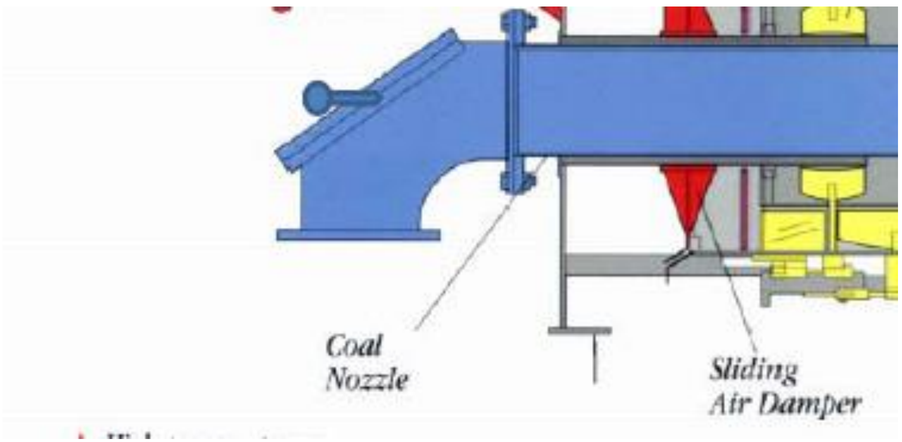



Variation of coal flows in the four corners in Unit 2
Sample Weight (grams)
250
200
150
100
50
0
Corner 1
Corner 2
Corner 3
Corner 4
Mill A
Mill C
Mill D
Mill E
Mill F
Average

Case studies

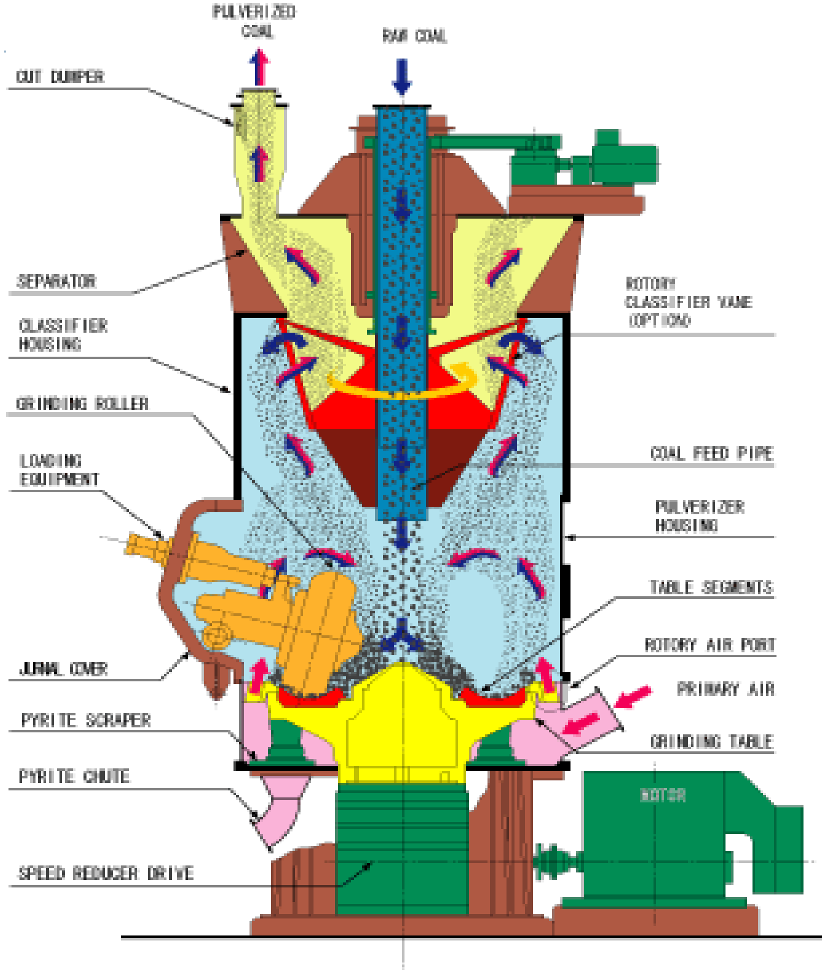
- Mill outlet temperature measurement
  - Cold Junction Temp. Compensation Error
    - Temp. monitoring in each pipe

- PF sampling point and sampling method



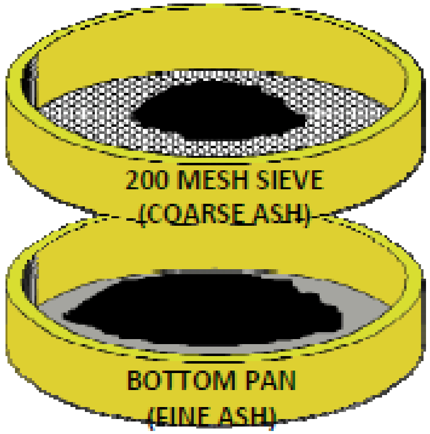
Case studies

- Leakage in central feed pipe
  - Poor fineness in particular line
- Holes in classifier vanes
  - Poor fineness



High Unburnt in Fly Ash

Fineness or Air distribution problem?



PLACE 20 GRAMS OF ASH ON STACKED 200 MEASH AND PAN AND SHAKE FOR 20 MINUTES.

DETERMINE UNBURNT OF RESIDUE ON 200 MESH SCREEN AND IN PAN

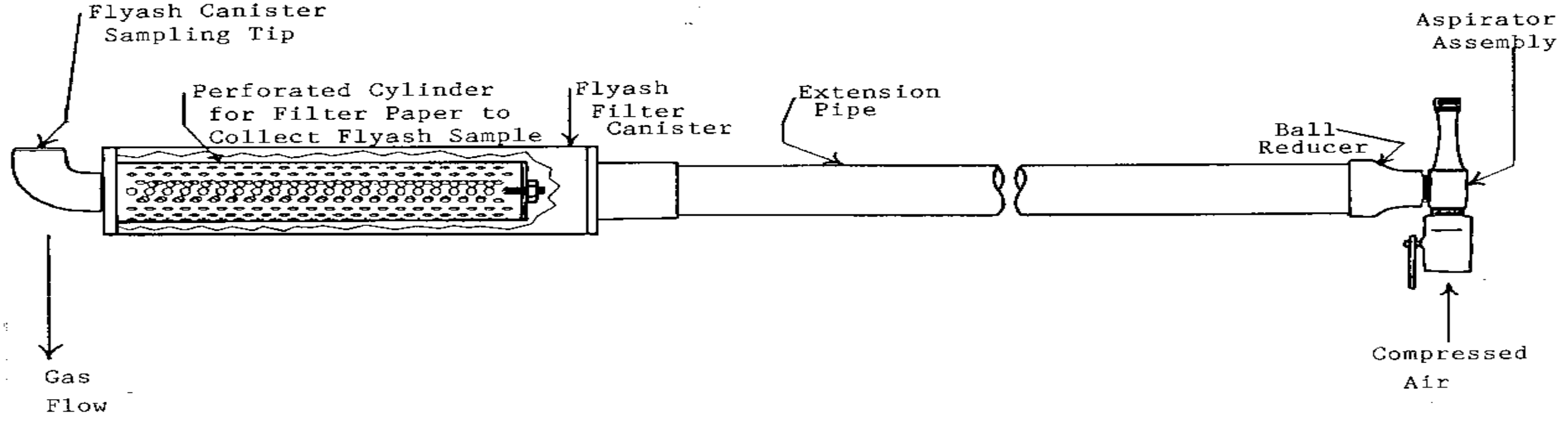
Higher Unburnt in the pan indicates Air distribution problems while higher Unburnt in the sieve would indicate milling system problems

In one case 53% of the ash retained on a 200 sieve was coarse & high in carbon (8%), while the -200 was soft, fluffy and had less unburnts (1%). This is indicative of poor fineness & problems in milling system.

Unburnt Carbon Loss (Controllable)

- $C_{unburnt}$ is a measure of effectiveness of comb. process
- $C_{unburnt}$ includes the unburned constituents in FA and BA
- +50 PF fineness fractions to be < 1%
- Focus to be on FA due to uncertainty in repeatability and representativeness

FA sampling (HVS)



Factors - Unburnt C Loss

- Type of mills and firing system
- Furnace size
- PF fineness (Pulverizer problems)
- Coal FC/VM ratio, coal reactivity
- Insufficient excess air in combustion zone
- Air damper / register settings
- Burners design / condition
- Burner balance / worn orifices
- Primary Air Flow / Pressure

Thanks

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