Optimization of VRM Operation

- Do not believe screen values unless you have checked them
- Continuously change Process Parameters and document results to find Optimum
- Optimum is highest capacity at lowest power consumption
- Be sensitive to changes of feed material and adapt parameters
- Focus on Relevant Process Parameters only
- Optimize Control Loops

Relevant Process Parameters

- Product Rate and Product Fineness (T/H)
- Classifier Speed (rpm)
- Grinding Force and N2 Pressure
- Power Consumption Main and Fan Drive (KW)
- Air Flow Profile (am3/h) and Pressure Profile (mbar)
- Availability (% relative to kiln)
- Grinding Bed Height (mm) and Variations (mm)

Product Rate and Product Fineness

→ Correct Feed Rate to measured moisture

→Check fineness on 90 and 212 micron

Comments:

•Do not over grind

•Check burnability and 212 micron sieve

Classifier Speed

→ Check Screed Indication with Actual Speed

→ Fineness is not linear to Classifier Speed

Influenced by:

- Air Flow
- Target Fineness
- Material

Grinding Force and N2 Pressure

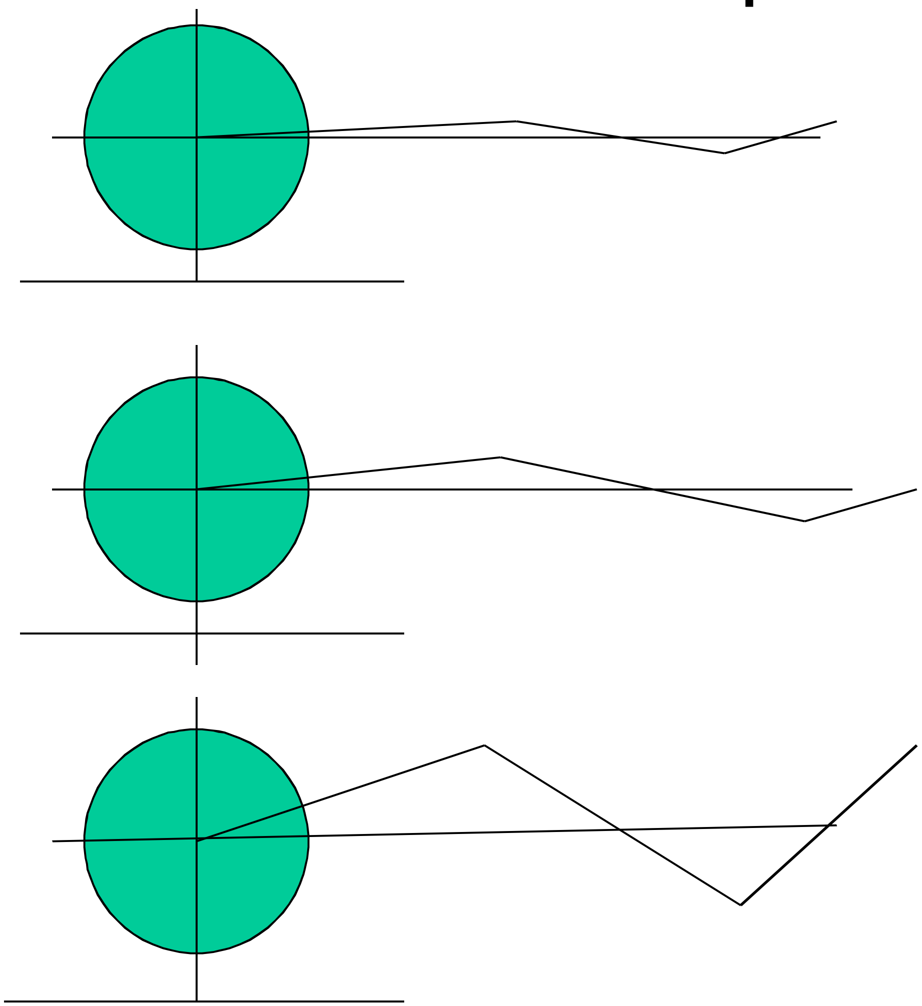
→ Grinding Force as low as possible, as high as necessary for low specific power consumption

→ N2 Pressure as low as possible, as high as necessary for soft running

Influenced by:

- Hardness of Feed Material
- Grain Size of Feed Material

What is the Optimum N2 Pressure ?



N2 Pressure bed too <u>low</u>, -> Rough Running

N2 Pressure, <u>OK</u>, ->controlled roller movement, Efficient Grinding

N2 Pressure too <u>high</u>, ->Excessive Roller Movement, Inefficient Grinding, Rough Running

Power Consumption Mill Drive

→ Calculate to shaft power

Influenced by:

Grindability of Raw Material

- Grinding Fineness
- Classifier Design
- Grinding Bed Height / Variations
- Dam Ring Height
- Air Flow
- Temperature Level
- Condition of Grinding Elements

Power Consumption Fan Drive

→ Calculate to shaft power, using power factor, motor efficiency

Influenced by:

- Fan Efficiency
- Load on Fan
- Dust Load of Gases
- Temperature of Gases
- Total Air Flow at Fan Inlet
- Total Pressure at Fan Inlet

Air Flow Profile

→ Check for False Air Leakage because:

- False air after nozzle ring reduces grinding capacity

- Any false air reduces drying capacity

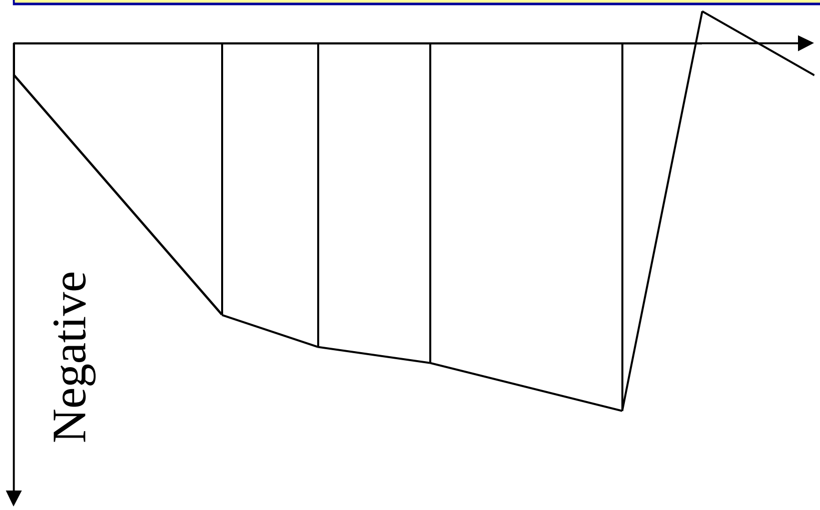
Influenced by:

Expansion Joints

- Flanges
- Pull Rod Seals
- Negative Pressure
- Feeding Device to Mill
- Air Locks after Filter / Cyclones

Pressure Profile

→ Draw Up Curve



Influenced by:

- Mill Inlet Pressure
- Nozzle Ring Coverage
- Classifier Speed
- Dam Ring Height
- Mill Load
- Material Blockage in Hot Gas Channel
- Size and Condition of Filter / Cyclone
- Air Flow

Availability

→ T/H X H = Total Production (T)

Influenced by:

- Maintenance
- Analyze Mill Stops
- Schedule Maintenance
- Spare Parts Availability

Basic Questions

For Operation of VRM s

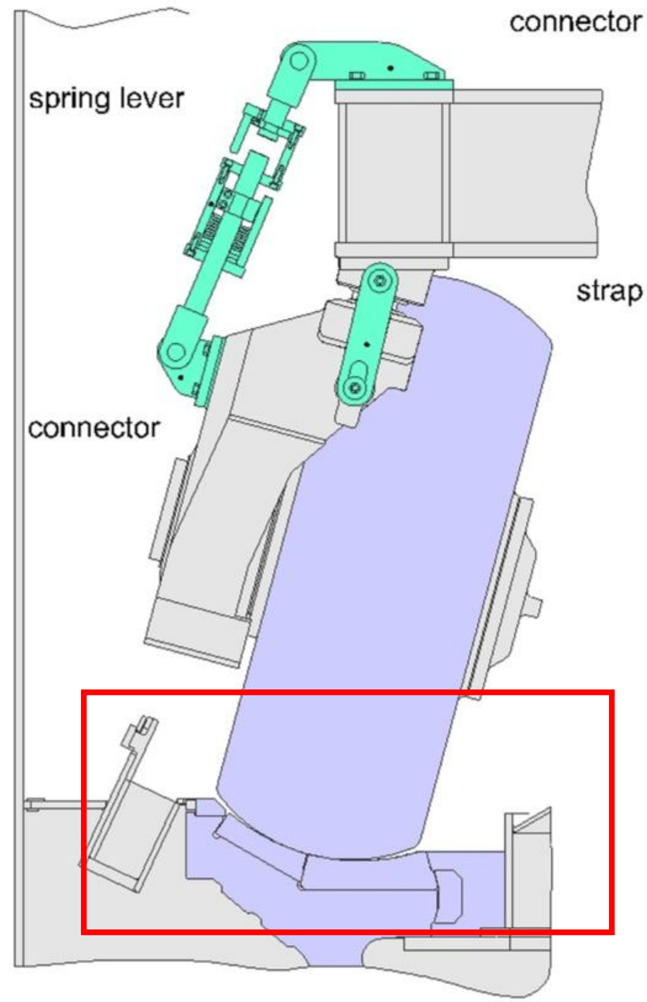
What is a Grinding Bed ?

Grinding bed is the material layer between the roller and the table

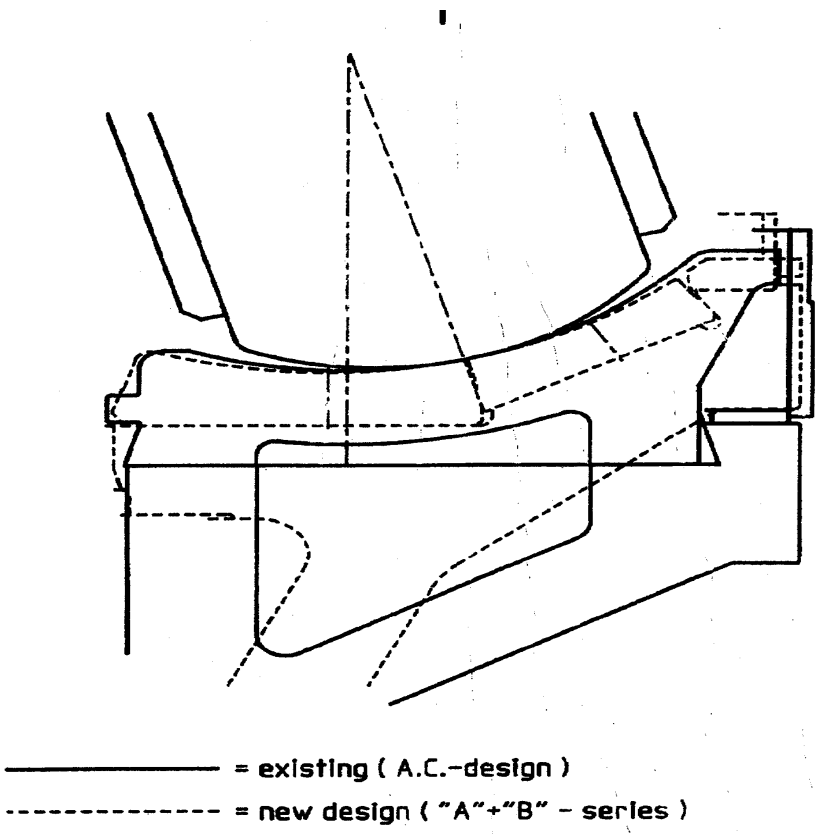
It transmits the entire roller force and mill power

It is the key issue to successful operating of a VRM !!!

Determined by:
- •Feed Material size
- •Feed Material Moisture
- •Dam Ring Height
- •Grinding Fineness
- •Air Speed in nozzle ring

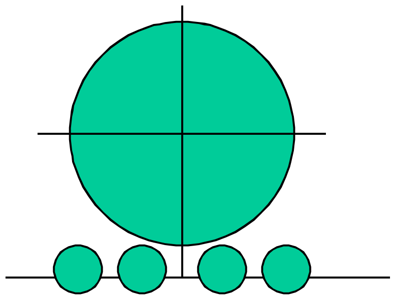


Redesigned – Table Segments

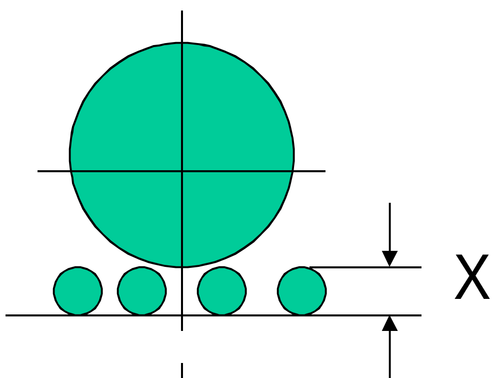


- More Flat Grinding Bed
- Less Weight to be Handled
- Longer Lifetime of Table Segments

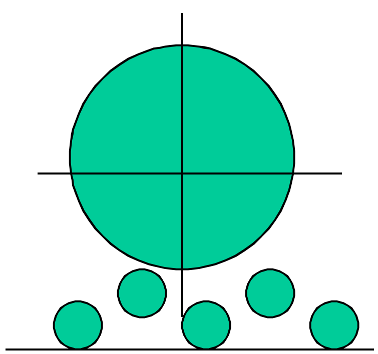
What is the Optimum Grinding Bed Height ?



Grinding bed too low, -> Vibration



Grinding bed, OK, ->little Vibration, Efficient Grinding



Grinding bed too high, ->Vibration Inefficient Grinding

How to Calculate your Dust Load ?

$$\text{Dust Load} = \frac{\text{Mill Product (t/h)} \times 1000 \times 1000}{\text{Air Flow at Mill Outlet (am3/h)}} \quad \text{in (g/am3)}$$

Typical: 400 – 800 g/am3

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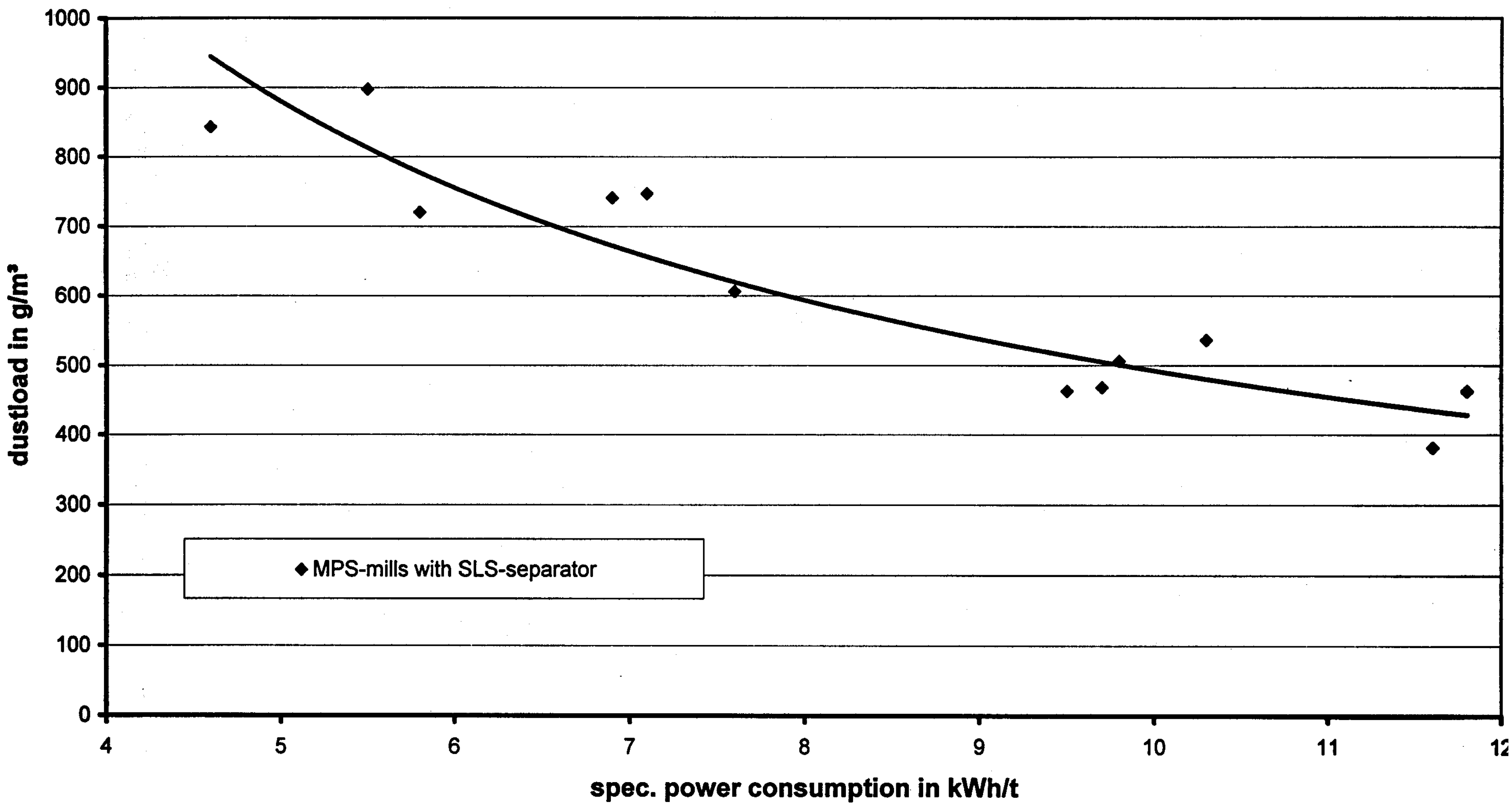
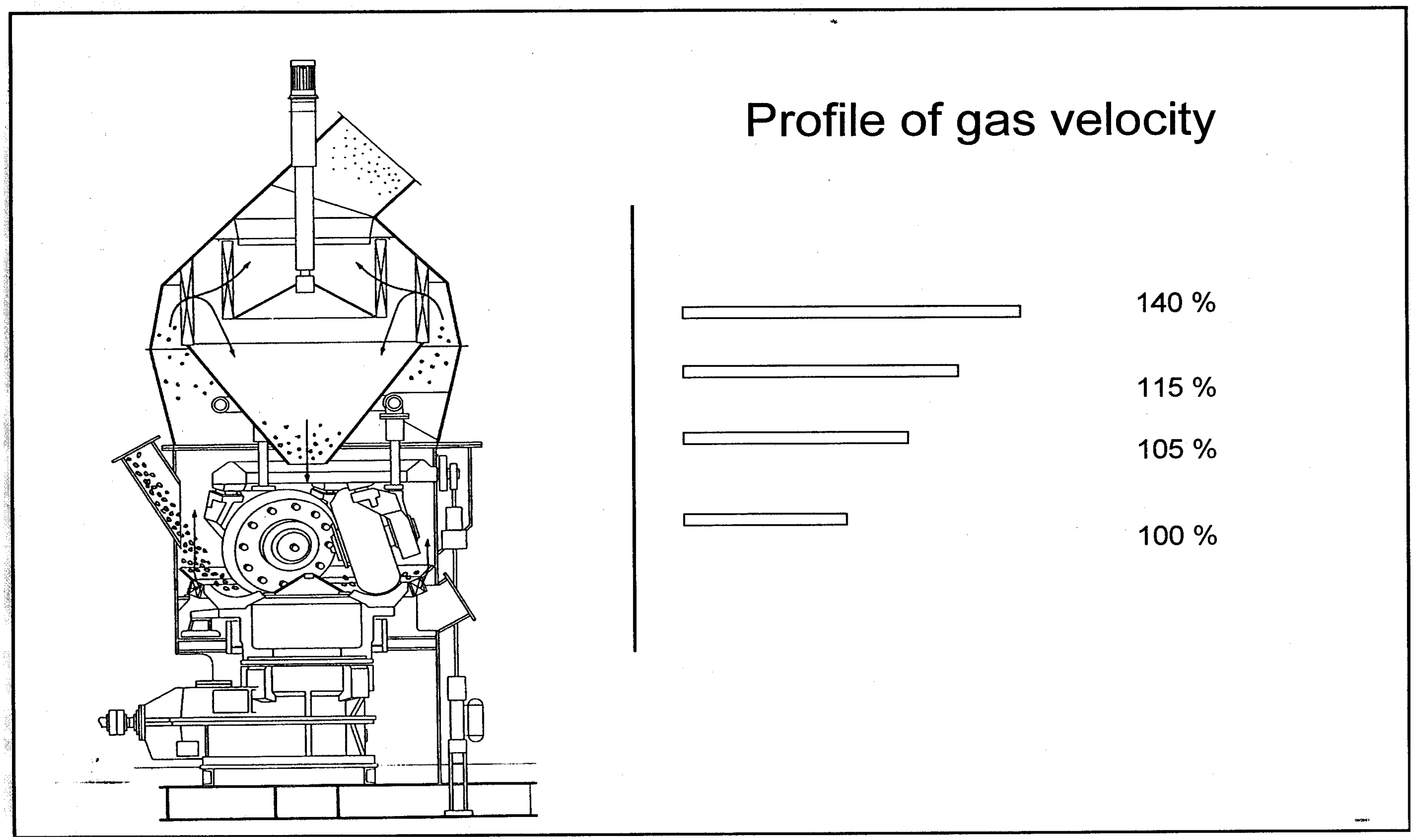
What determines your Dust Load ?



Why a Lower Pressure Loss ?



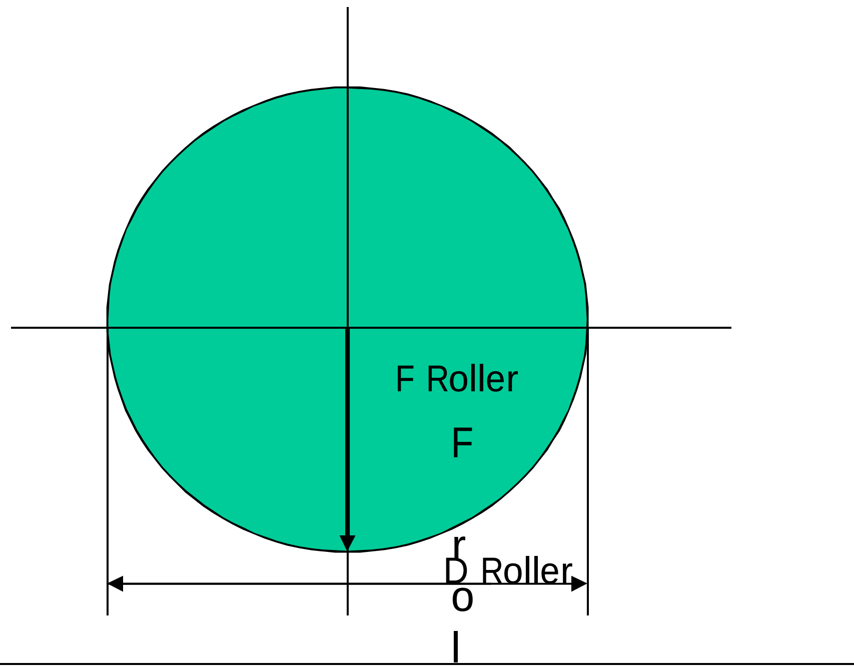
Relevant Mill Parameters

- Diameter and Width of Grinding Rollers (m)
- Table Track Diameter (m)
- Table Speed (rpm)
- Dam Ring Height (mm)
- Open Area of Nozzle Ring (m2) and possible coverage (m2)
- Roller Force (KN)
- N2 Prefill Pressure (bar)

Basic Calculations

For Operation of VRM s

Calculation of Specific Roller Force



$$F_{\text{Roller}} = FR_{\text{weight}} + FR_{\text{hydraulic}} \quad (KN)$$

$$A_{\text{Roller}} = W_{\text{roller}} \; X \; D_{\text{roller}} \quad (M2)$$

$$P_{\text{Roller}} = F_{\text{Roller}} \,/\, A_{\text{Roller}} \quad (KN \,/\, M2)$$

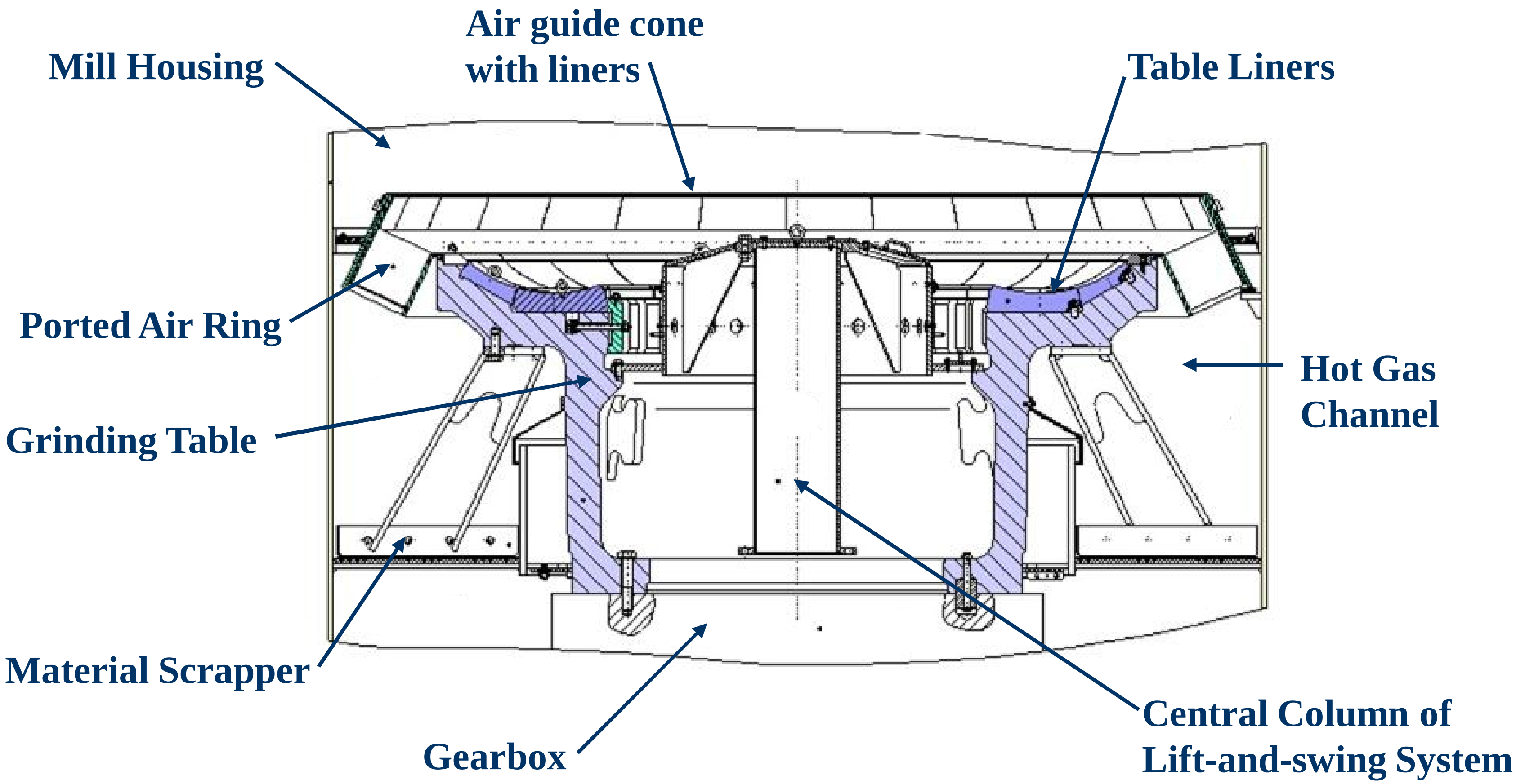
Calculation of Fan Motor Power

$$P_{shaft} = \frac{\text{Flow (am3/h)} \times \text{Static Pr. (mbar)} \times F_{dust} \times F_{dyn}}{\text{Efficiency} \times 9.81 \times 3600}$$

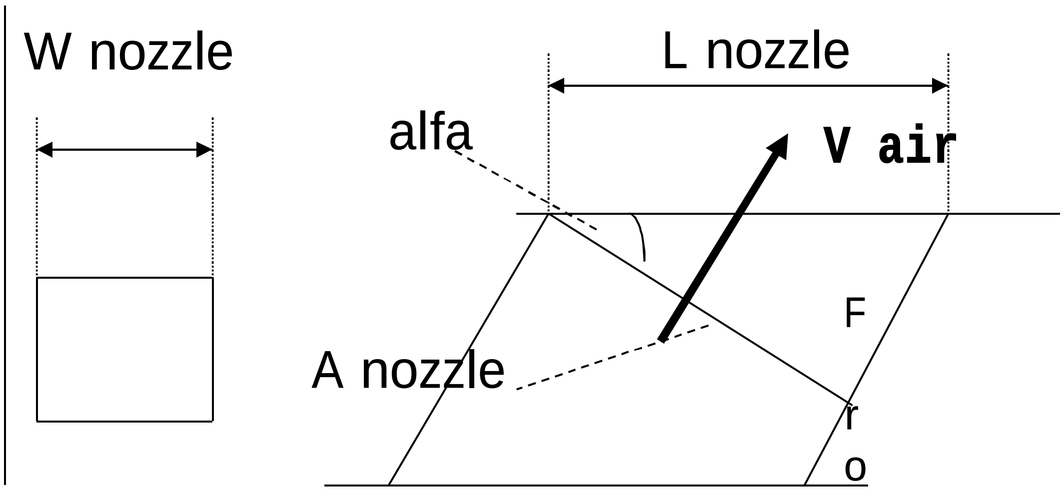
Typical: Efficiency → 0.8
F_{dust} → 1.0 – 1.02
F_{dyn} → 1.02 – 1.03

Valid for Fan without Damper Losses Only

Calculation of Nozzle Ring Air Speed 1



Calculation Air Speed in Nozzle Ring 2

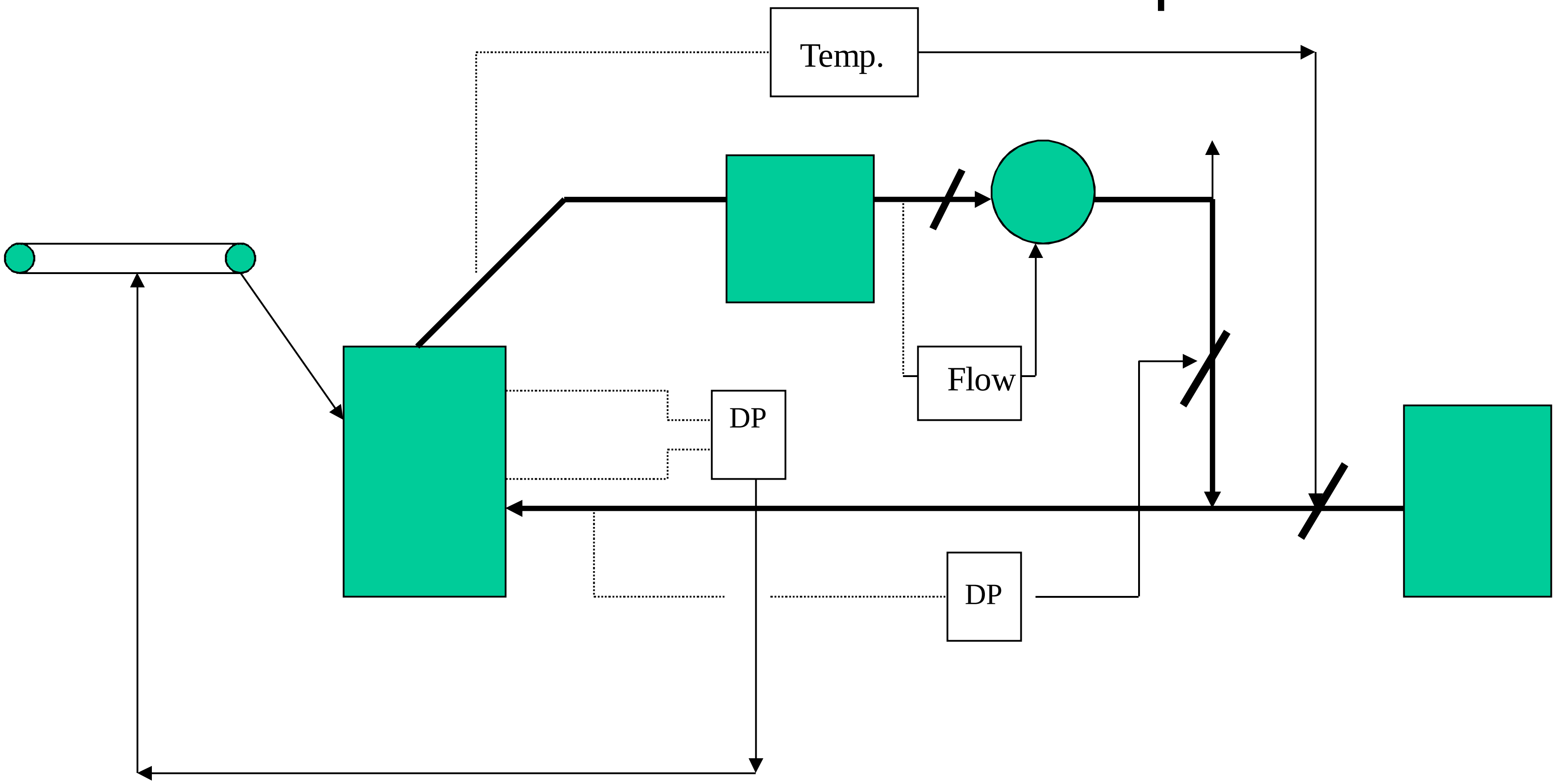


A nozzle = L X W X cos (alfa) X No Nozzles (m2)

V air = V after Classifier (m3/h)

Typical: 30 – 50 m/s w external recirculation
50 – 80 m/s w/o external recirculation

Recommended Control Loops



Basis: Constant Air Flow Through Mill

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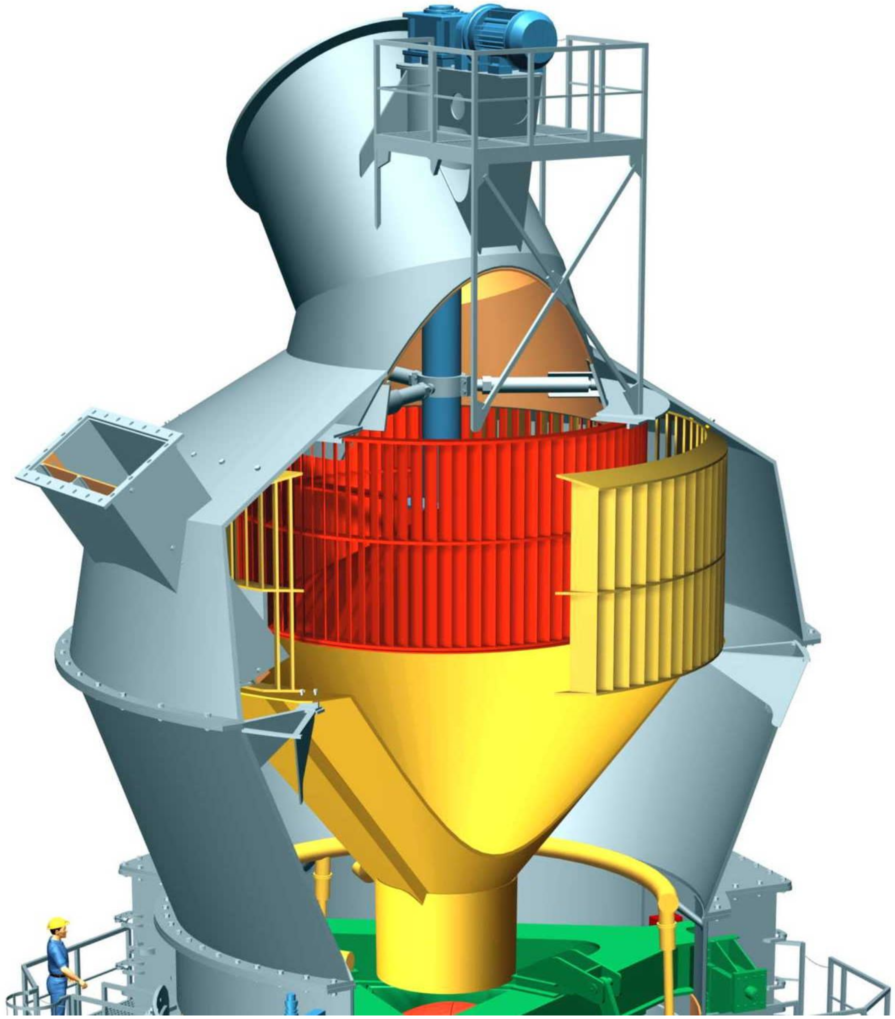
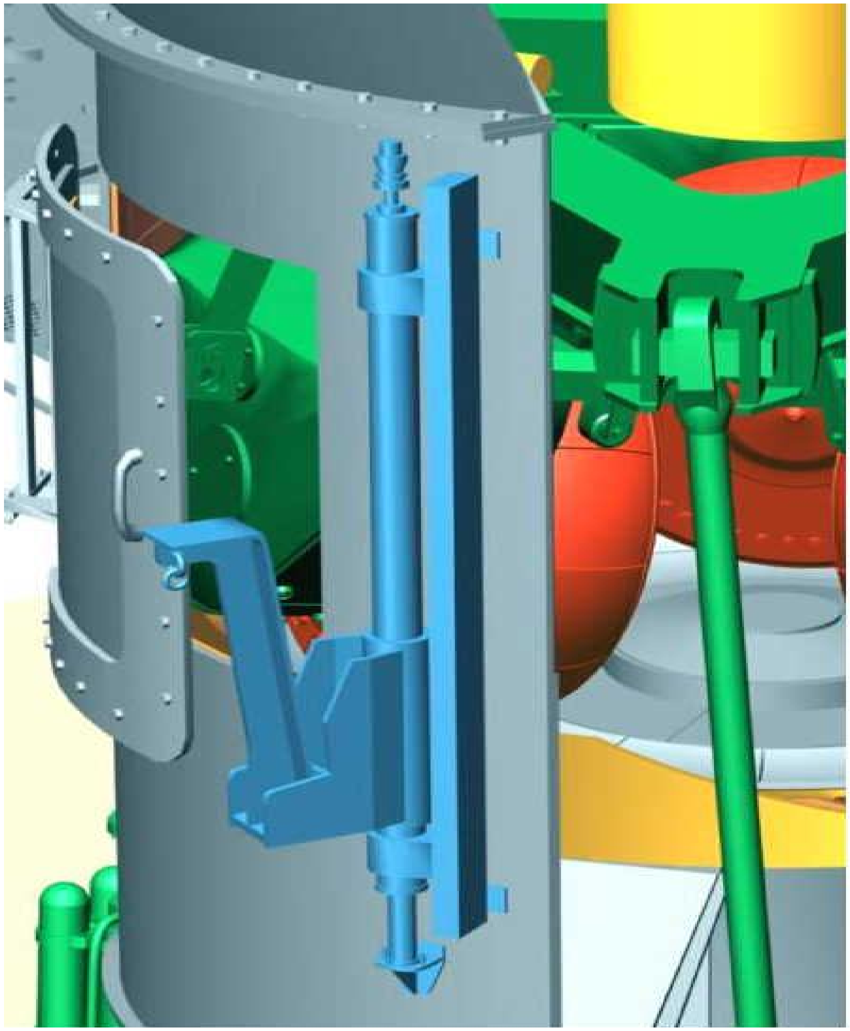
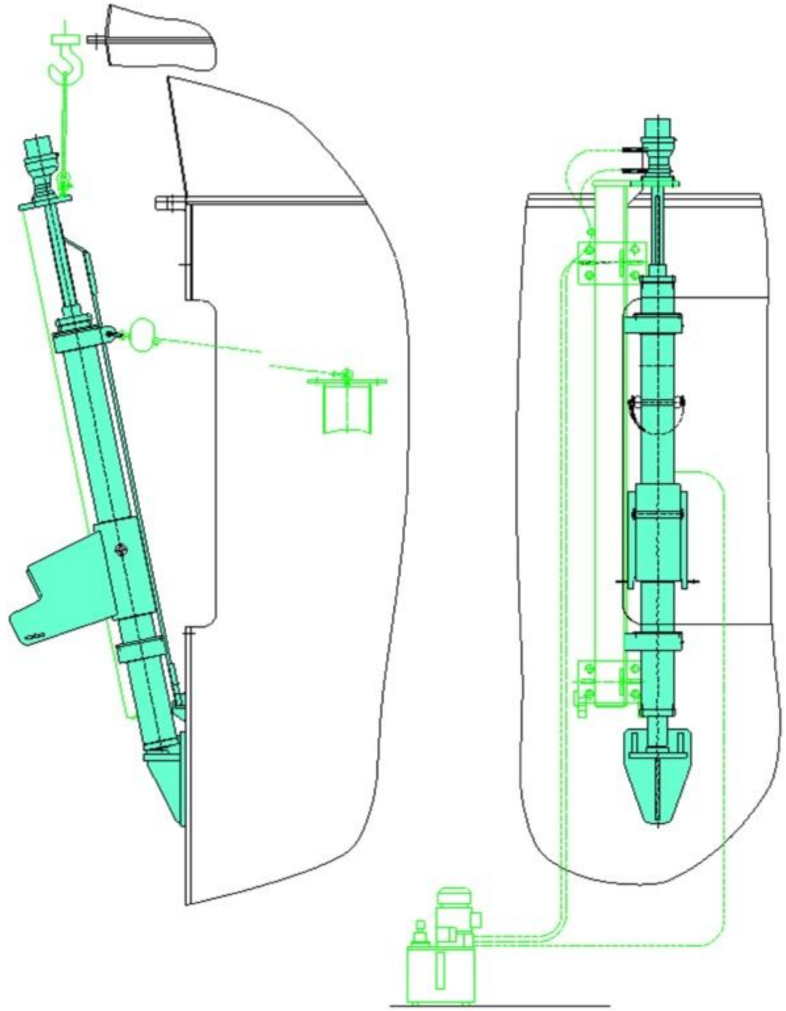
Basic Design Features

Classifier Design

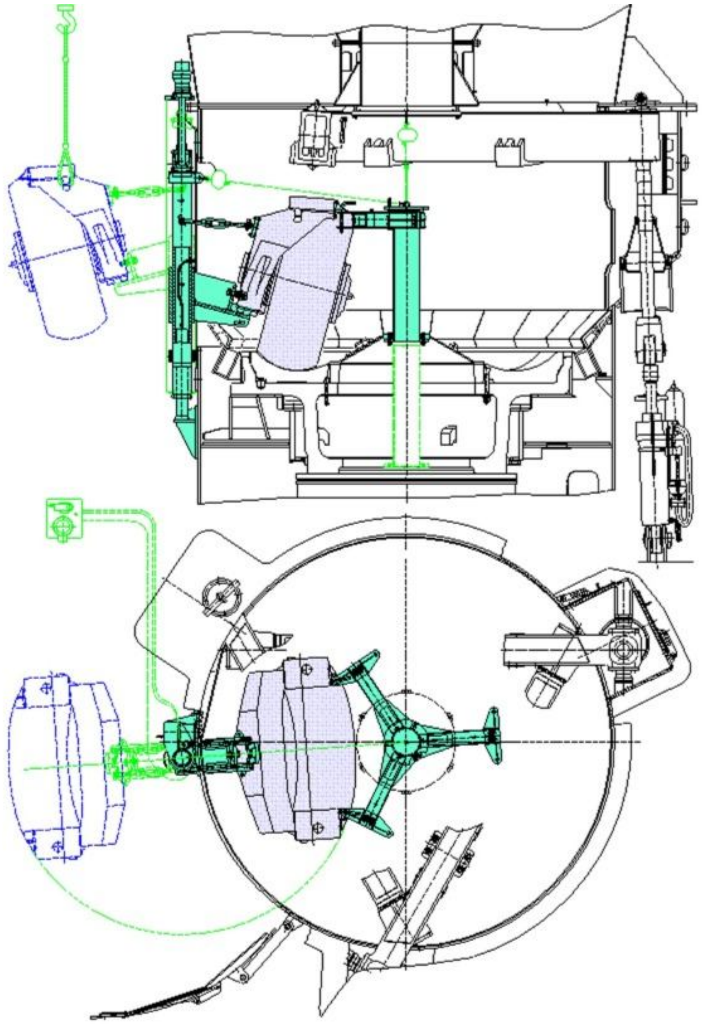


Lift-and-swing Installation





Removal Of Roller Assemblies



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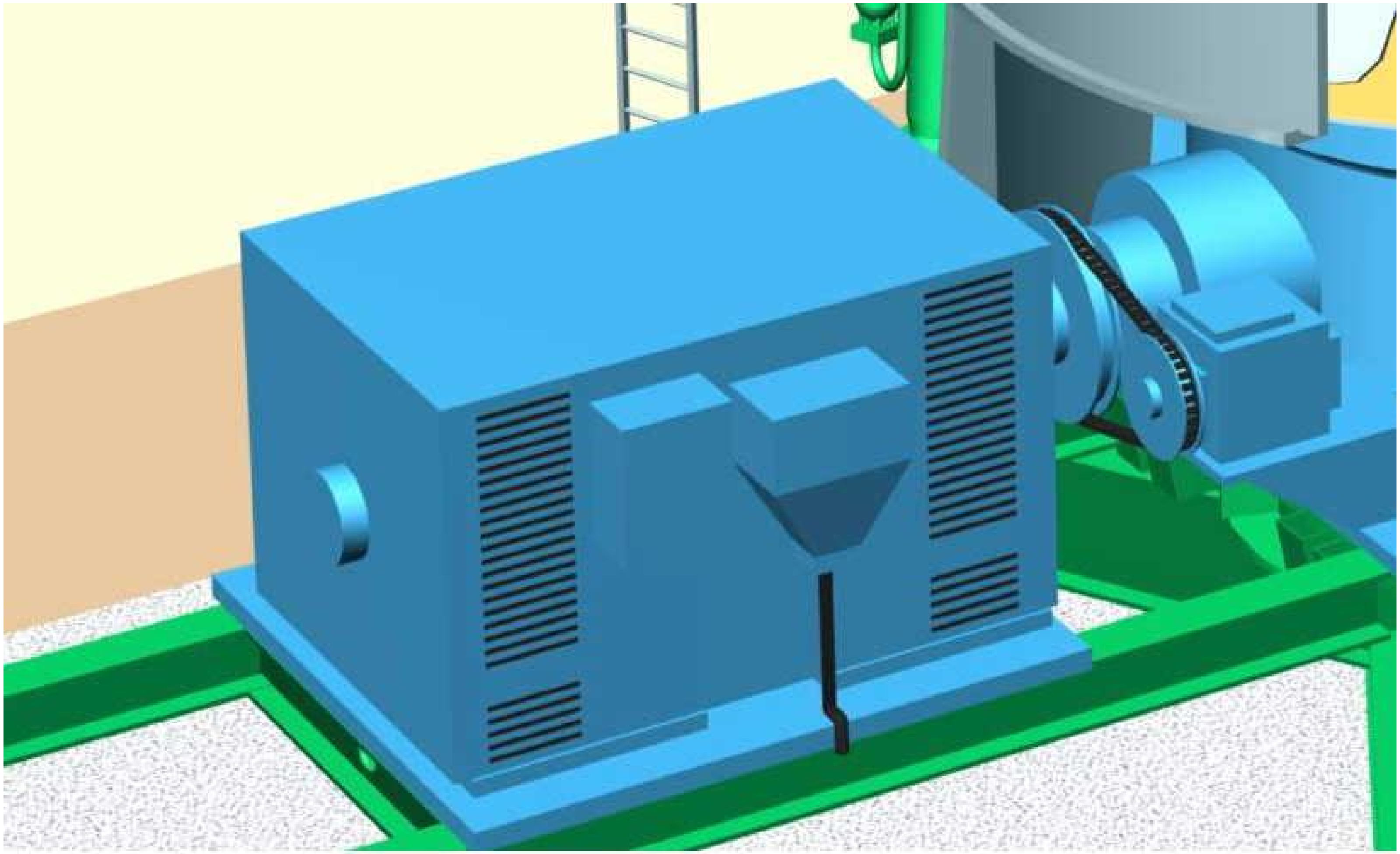
Vertical Roller Mills

Main Motor And Maintenance Drive



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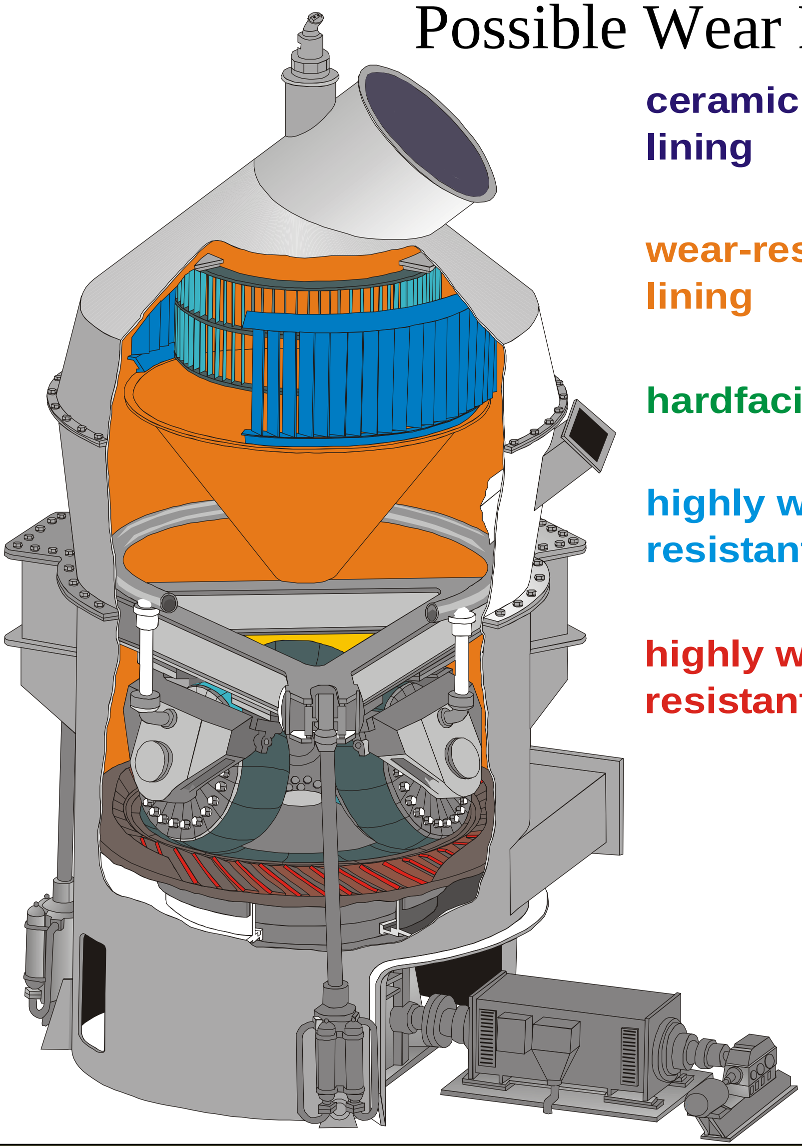
Possible Wear Protection



ceramic lining

wear-resistant lining

hardfacing

highly wear-resistant material

highly wear-resistant cast iron

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Vertical Roller Mills