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 low, -> Rough Running

N2 Pressure, OK, -> controlled roller movement, Efficient Grinding

N2 Pressure too high, -> 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

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
Vertical Roller Mills

Availability

→ \( \frac{t}{h} \times h = \text{Total Production (T)} \)

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

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= existing (A.C.-design)
= new design ("A"+"B" - series)
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?

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

Typical: 400 – 800 g/am3
What determines your Dust Load?

Graph showing the relationship between specific power consumption in kWh/t and dust load in g/m². The graph includes data points and a trend line, indicating a negative correlation. The data points are labeled as MPS-mills with SLS-separator.
Why a Lower Pressure Loss?

Profile of gas velocity

- 140 %
- 115 %
- 105 %
- 100 %
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

\[ F_{\text{Roller}} = F_{\text{R weight}} + F_{\text{R hydraulic}} \quad (\text{KN}) \]

\[ A_{\text{Roller}} = W_{\text{roller}} \times D_{\text{roller}} \quad (\text{M}^2) \]

\[ P_{\text{Roller}} = \frac{F_{\text{Roller}}}{A_{\text{Roller}}} \quad (\text{KN} / \text{M}^2) \]
Calculation of Fan Motor Power

\[ P_{\text{shaft}} = \frac{\text{Flow (am}^3/\text{h}) \times \text{Static Pr. (mbar)} \times F_{\text{dust}} \times F_{\text{dyn}}}{\text{Efficiency} \times 9.81 \times 3600} \]

Typical:
- Efficiency \( \rightarrow 0.8 \)
- \( F_{\text{dust}} \rightarrow 1.0 \) – 1.02
- \( F_{\text{dyn}} \rightarrow 1.02 \) – 1.03

Valid for Fan without Damper Losses Only
Calculation of Nozzle Ring Air Speed 1

- Mill Housing
- Ported Air Ring
- Grinding Table
- Material Scrapper
- Air guide cone with liners
- Table Liners
- Hot Gas Channel
- Central Column of Lift-and-swing System
- Gearbox
Calculation Air Speed in Nozzle Ring 2

\[ A_{\text{nozzle}} = L \times W \times \cos(\alpha) \times \text{No Nozzles} \, (m^2) \]

\[ V_{\text{air}} = V_{\text{after Classifier}} \, (am^3/h) \]

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
Basic Design Features
Classifier Design
Lift-and-swing Installation
Removal Of Roller Assemblies
Main Motor And Maintenance Drive
Possible Wear Protection

- ceramic lining
- wear-resistant lining
- hardfacing
- highly wear-resistant material
- highly wear-resistant cast iron
Vertical Roller Mills