How to adjust the dam ring of a vertical mill

Introduction

- The dam ring is an important device for optimising the performance of a vertical mill.
- It is used to adjust the height of the material bed in the mill, which directly affects the grinding efficiency.
- A low material bed height will promote more efficient grinding, but generally the lower the material bed the higher the vibrations. This is because of the reduced cushioning effect by the bed on the grinding forces. Therefore the optimum bed depth is the lowest possible while still maintaining a safe level of mill vibrations.
- Normally the dam ring is adjusted to compensate for wear of the grinding elements with the objective of maintaining optimum performance throughout the life of the liners.
- Occasionally, adjustment of the dam ring may be necessary for other reasons than wear, for example significant changes in material properties or a modification of the mill such as a new separator, but always the objective is the same: to optimise the mill efficiency by changing the bed depth in the mill.

Safety aspects

- Conducting this procedure means entering the mill with exposure to many hazards, including:
  - Moving machinery
  - High noise level
  - Heat
  - Dust
  - Dust laden gases
  - Working in confined spaces
  - Working at height
  - Trip hazards
  - Falling objects
  - Toxic gases in raw and coal mills
- Before entering the mill electrical isolation of the mill and associated equipment must be ensured and all persons entering must have their own personal lock out, in accordance with the plant procedures.
- It is imperative that a risk assessment be made and all the necessary safety procedures and personal protective equipment applied.

How to adjust the dam ring of a vertical mill

Prerequisites

- Ability to adjust the dam ring: usually the ring is increased by welding a rolled steel bar or reduced by cutting off the required amount. Alternatively some mills are fitted with dam rings made of several layers of steel bars that are bolted to the table in which case the dam is adjusted by adding or removing the appropriate number of bars for the desired change in height.
- Reliable measurement of material bed depth: the best results have been achieved by using the roller and string and ultra-sonic methods to continuously measure the extension of all of the hydraulic cylinders.
- Know the normal bed depth (usually in the range 50 – 80 mm)
- Know the normal safe operating level for mill vibration; the actual level depends on the location of the vibration monitor. The Lafarge standard is to measure the vertical vibration on the gearbox casing at the input shaft. At this point the normal vibration level is 2-3 mm/s.
- Cross check mill feed rate calibration, ideally with a truck weigh off, or belt weigh off, but with silo levels at a minimum
- Ensure that the hydraulic accumulators are properly charged with nitrogen and are free from any leaks

Time frame

- A single adjustment of a dam ring can take 8 hours so any changes need to be well planned.
- Frequency of adjustment normally depends on the wear rate of the mill liners. In some mills, with liners that have a high wear rate (<8000 hours lifetime) it may be necessary to adjust the dam ring every 2-3 months whereas in other mills, where the liners have a longer life expectancy, annual adjustment may suffice.

How to adjust the dam ring of a vertical mill

Action Steps

1. Conduct checks on a new table

- Check that the table and roller profile are correct and that the roller positioning on the track is correct.
- Check that the dam ring height is the same as the previous new table.
- Check that the dam ring has been placed on the same diameter of the table as it was before.
- Re-calibrate bed depth monitors.

A dam ring placed on a smaller diameter, even if it is only a few centimetres smaller, will increase the bed depth to a greater extent than one of the same height placed at the edge of the table. Try to avoid changing the dam ring position on the table diameter as this will change all your previous reference points.

2. Observe initial operation

- After stabilising operations, observe the mill's performances for about 1 week.

In particular, pay special attention to the relative levels of:
- Mill rejects
- Mill pressure loss
- Vibration
- Bed depth
- Mill power

- Note if there are any difficulties reaching nominal capacity and / or reaching normal grinding pressure.
- The performance of a new table with new rollers will differ from that of a new table with worn rollers.
- So the normal starting height of the dam ring may have to be adjusted.

3. Adjust the initial dam ring

- A mill that tends to have a high level of rejects and high pressure loss with a lower than normal bed depth and higher vibration indicates that the dam ring is too low. The mill drive power will also be low.
- In this case plan to increase the dam ring height by 10-20 mm
- On the other hand, if the rejects and the pressure loss are low, mill power high, bed depth high and vibration low, then the dam ring is too high.
- In this case plan to reduce the dam ring by 10-20mm during the next maintenance day.

The relationship between dam ring height and bed depth is not a direct one because the depth of the bed depends on other factors such as material properties, water injection, relative profile of rollers and table. This is why the adjustment has to be done by trial and error.

- Continue tracking the mill's performances and make further adjustments if necessary to bring the mill parameters back into the optimum range.

4. Adjust the dam ring to account for the track and roller wear

- Monitor the wear of the table and roller liners by measuring their profiles at regular intervals. If the lifetime of the liners is 1 year then aim to measure the liners at least once a month,; if the lifetime is more than two years then the liners should be measured every two months, and so on and so forth.

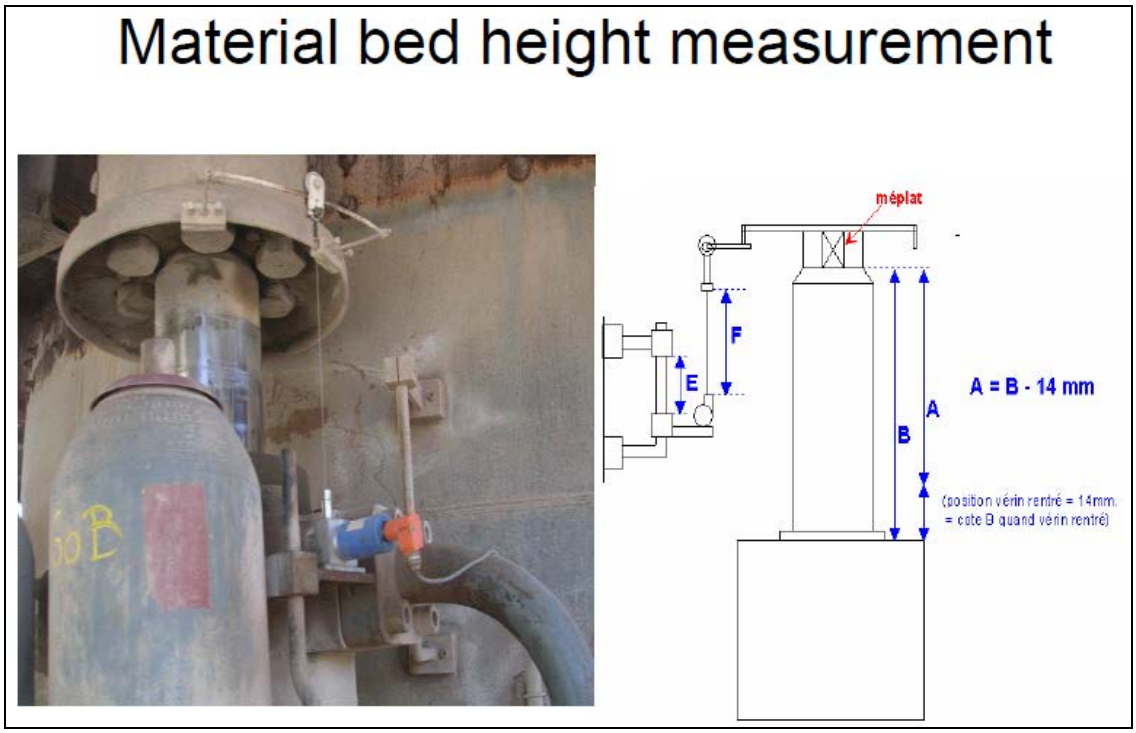
The relationship between the height of the dam ring and the depth of the bed is not a direct one because the depth of the bed also depends on factors such as material properties, water injection, relative profile of rollers and table. This is why any adjustments have to be done by trial and error.

- Wear and the impact of wear on mill performances have to be monitored in order to determine when the dam ring has to be adjusted again.
- Likewise the level of rejects, mill pressure loss, mill power, bed depth and vibration have to be monitored.
- However, it is usually the case that as the track wears the height of the dam ring has to be reduced in order to avoid excessive bed depth. During the latter stages of the life of the liners it is sometimes necessary to increase dam ring and sacrifice mill efficiency in order to keep vibration under control. This is because of the uneven wear of the rollers and track that cause high and low points in the material bed, which in turn need a deeper bed to limit vibration.
- Building up a history by recording any changes to the height of the dam ring, the wear of the track and the mill running hours, production and operating parameters, will make it easier to determine adjustments for the next set of liners.

Appendix

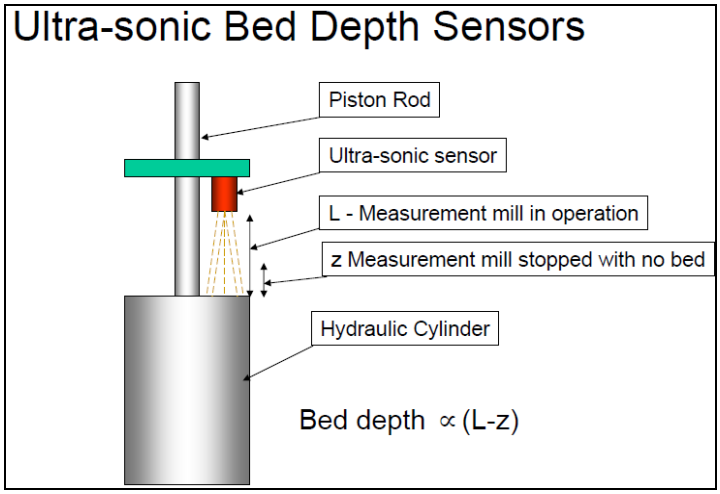
1. Bed depth measurement

Roller & string method:



(extracted from Vertical Raw Mill Technical Agenda Study, annex 16.1, July 2007)

Ultra-sonic distance measurement:



Appendix

Ultrasonic Sensors

500mm, 2m, 4m and 6m Sensing Range

Ultrasonic *Analog Output*

Analog Current and Voltage Output
30mm Cylindrical

- 500mm (20in.), 2m (6.5ft.), 4m (13ft.) and 6m (20ft.) sensing ranges
- 4-20mA/20-4mA and 0-10V/10-0V analog output
- Temperature compensation
- Potentiometer-free span adjustment
- Programmable output via programming plug or RS-232 interface

Specifications

ADJUSTABLE SENSING RANGE	50-500mm
UNUSABLE AREA	0-50mm
MODEL NUMBER(S)	UC500-30GM-IUR2-V15
OUTPUT: Suffix /UR2	Analog
ANALOG CURRENT OUTPUT #1	4-20mA or 20-4mA (load ≤500Ω)
ANALOG VOLTAGE OUTPUT #2	10-0V or 0-10V (load ≥1000Ω)
SHORT CIRCUIT AND OVERLOAD PROTECTION	Yes
REVERSE POLARITY PROTECTION	Yes
SUPPLY VOLTAGE	10-30VDC
LED(S)	Yes (4)
POWER CONSUMPTION	≤900mW
STANDARD TARGET	100mm x 100mm
TRANSDUCER FREQUENCY	360kHz
ELECTROMAGNETIC COMPATIBILITY COMPLIANCE	NEMA ICS6-2000 Consult factory
RESPONSE TIME	21ms min/50ms factory setting
REPEATABILITY	±0.1% of full scale
LINEARITY	±0.2% of full scale
RESOLUTION	max. span value - min. span* / 4000
PROTECTION IEC	IP65
TEMPERATURE DRIFT	±2% of final value
TEMPERATURE RANGE WORKING	-14°F to +158°F
TEMPERATURE RANGE STORAGE	-40°F to +185°F
HOUSING MATERIAL	303 Stainless steel
TRANSDUCER	Epoxy resin/ silica composite
BLACK RING	Polyurethane
APPROVALS cULus General Purpose	Yes
APPROVALS CE General Purpose	Yes
ELECTRICAL CONNECTION	Quick disconnect type V15

*Minimum possible resolution is 0.05mm

Denotes a parameter which may be adjusted via RS-232 interface. Other parameters are accessible (i.e. to increase output stability).
Refer to pages 308-310 for more information.

290 PEPPERL+FUCHS

(extracted from Vertical Raw Mill Technical Agenda Study, annex 16.2, July 2007)

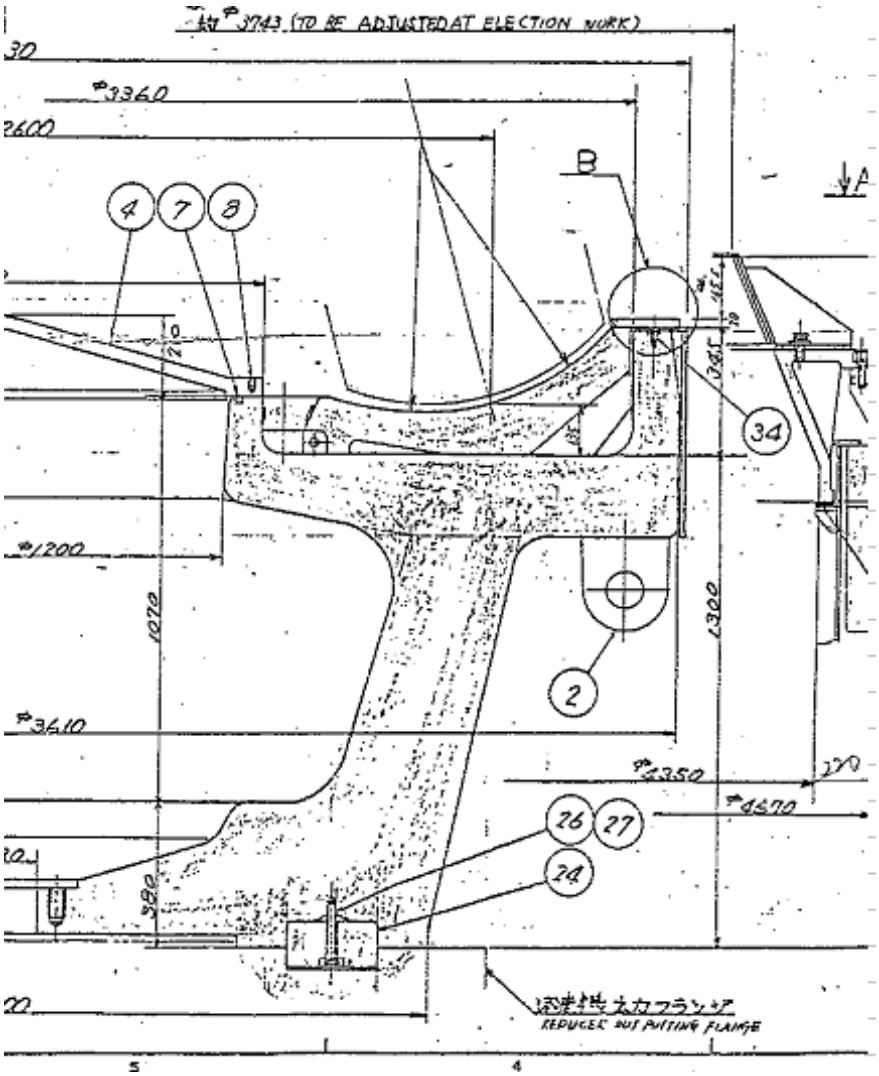
Appendix

2. Assessment of the installed dam ring (1)

Assessment of the VCM dam ring installed in Lafarge plants

CK260 - KAWASAKI

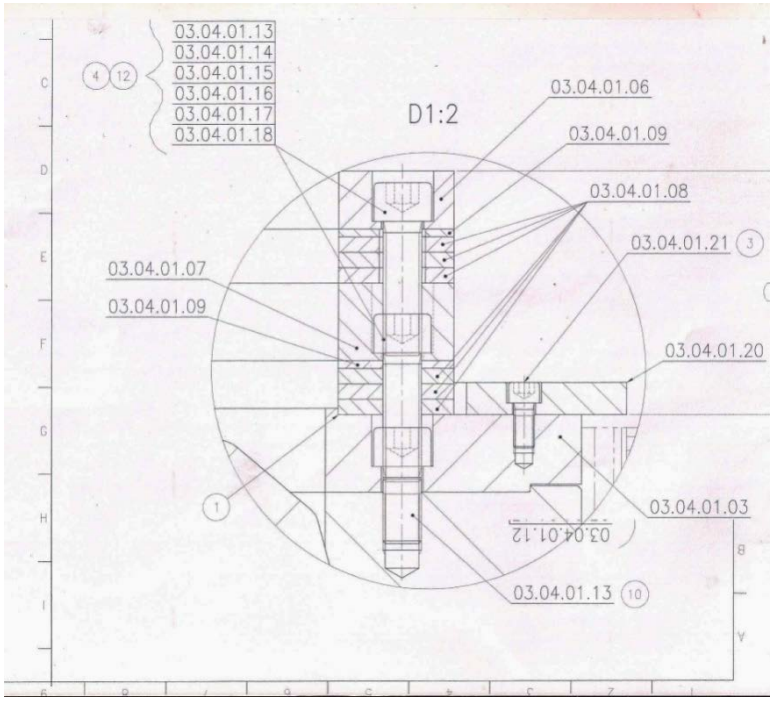
- The figure below shows the drawing of the installed dam ring on the slag mill CK260.
- The dam ring is located at the edge of the table and at the top of the grinding table (into the “B” circle)
- The total height of the dam ring is 54mm (Slag) – Kwangyang plant – Korea



Assessment of the installed dam ring (2)

OK – FLS

- The figure below shows the drawing of the installed dam ring on the OK mills
- The dam ring is located at the edge of the table
- The total height of the dam ring is
  - 130mm on the OK33-4 (Slag ; Cement) – Dongjun plant – China
  - 127mm on the OK39-4 (Cement) – Jalabiyeh plant – Syria



OK 39-4 – FLS - Jalabiyeh

- On the OK39-4 mills, trials were carried out on steps to stabilize mill operations by optimizing the height of the dam ring. The table below outlines the main steps followed to adjust the dam ring. Further information is available in procedure PR_GRI_P13-21_How_to_stabilize_VCM_v2.

Action on the height of the Dam Ring	From	To	Result
Increase by 12mm	115mm (Original Height)	127mm	More stabilized mill Increased Feed No change of water injections (Plant focus on feed increases)
Increase by 6mm	127mm	133mm	Stable mill but high power consumption limiting the feed
Reduce by 6mm	133mm	127mm	Action taken to return to optimum value to balance mill stability and feed capacity

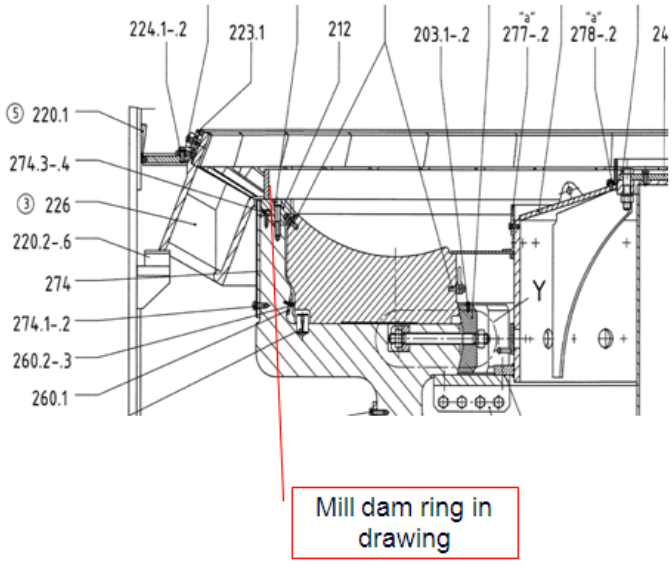
- The table below shows changes in the behaviour of the VCM installed at JALABIYED plant:
  - The height of the dam ring has been increased by 12mm.
  - In this case, a higher dam ring resulted in better VCM stability, a higher production rate, lower specific energy consumption, and a lower level of water injection.

Main parameters	Before Modification	After Modification
Mill Supplier	FLS	
Type of mill	OK 39-4	
Plant - Country	JALABIYED	
Product	CEM III/B-P	
Fineness of the finished product	3 752 cm²/g	3 774 cm²/g
VCM Ventilation		
VCM Feed	190,0 tph	230,0 tph
Absorbed Power of the VCM (table)	4 200 kW	4 140 kW
kWh/t (table)	22,1kWh/t	18,0kWh/t
Injected water	5 100 l/h	3 400 l/h
Injected water	27 l/t	15 l/t
Height of the Dam Ring	115 mm	127 mm

Assessment of the installed dam ring (3)

MPS – PFEIFFER

- The figure below shows the drawing of the installed dam ring on the PFEIFFER mills
- The dam ring is located at the edge of the table
- The total height of the dam ring is
  - 300mm on the MPS 5300 BC (Cement) – KUJAWY plant – Poland
  - 70mm on the MPS 4750 (Raw Material) - Dujiang Yan plant - China
  - 40mm on the MPS 3750 B (Raw Material) – PORT LA NOUVELLE plant – France

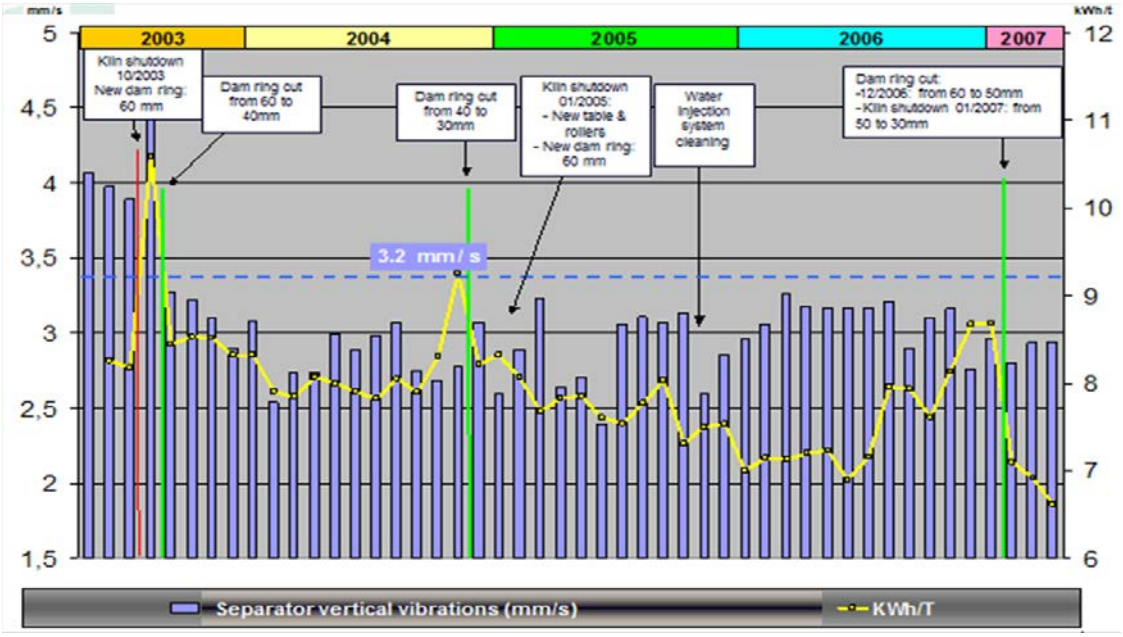


MPS 3750 – PFEIFFER – Port La Nouvelle

- The table below shows changes in behaviour of the Vertical Raw Mill installed at PORT LA NOUVELLE plant:
  - In 2003, the height of the dam ring has been reduced by 20mm.
  - In this case, a higher dam ring resulted in better VCM stability, a higher production rate, and lower specific energy consumption.

Main parameters	Before Modification	After Modification
Mill Supplier	PFEIFFER	
Type of mill	MPS 3750	
Plant - Country	Port La Nouvelle - France	
Product	Raw Material	
Fineness of the finished product	R100µm : 14%	R100µm : 14%
VCM Ventilation	90 Am3/s	90 Am3/s
VCM Feed	140,0 tph	160,0 tph
Grinding Pressure	145 bar	127 bar
Outlet temperature of the VCM	110,0 °C	110,0 °C
Height of the material bed	75 mm	61 mm
VCM Vibrations	9,1	5,7
VCM Delta P	30,5 mbar	39,0 mbar
Absorbed Power of the VCM (table)	1 485 kW	1 285 kW
kWh/t (table)	10,6kWh/t	8,0kWh/t
Height of the Dam Ring	60 mm	40 mm

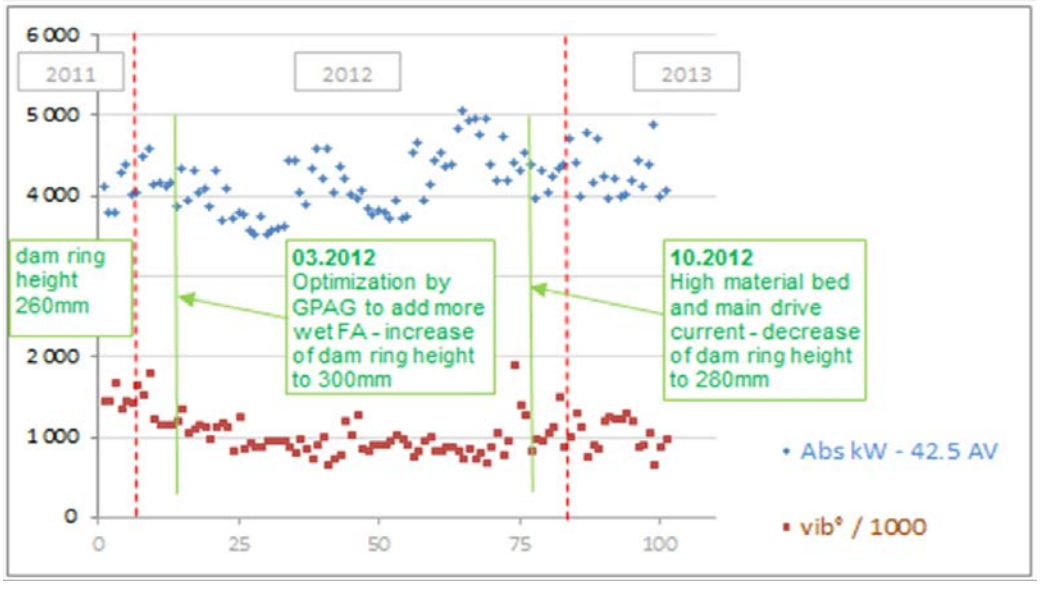
- The table below shows the evolution of the kWh/t versus the adjustment of the dam ring between 2003 and 2007:
  - The dam ring height has been adjusted to accommodate the wear of the table and keep a height of the material bed constant.



MPS 5300 – PFEIFFER - Kujawy

- The graphs below show the evolution of the absorbed power of the MPS 5300 installed at KUJAWY.
- The adjustments to the height of the dam ring were:
  - Initial height: 160mm (not mentioned on the graph)
  - Step 2, dam ring height: 260mm
  - Step 3 (March 2012), dam ring height: 300mm
  - Step 4 (October 2012), dam ring height: 280mm. VCM was operating temporally with hydraulic issues.
- Evolution of the absorbed power and of the vibration level in 32.5 BV.
  - The level of vibration decreases with an increase of the absorbed power.

- Evolution of the absorbed power and of the vibration level in 42.5 AV.



MPS 4750 – PFEIFFER - Dujiang Yan

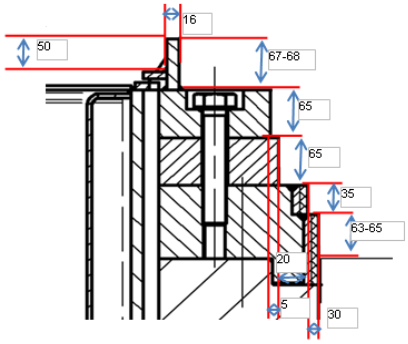
- The table below shows changes in the behaviour of the Vertical Raw Mill installed at Dujiang Yan plant:
  - The height of the dam ring has been reduced by 20mm.
  - In this case, a higher dam ring resulted in a better VCM stability, a higher production rate, and lower specific energy consumption.

Main parameters	Before Modification (Feb 1-9th)	After Modification (March 19th)
Mill Supplier	PFEIFFER	
Type of mill	MPS	
Plant - Country	China	
Product	Raw Material	
Fineness of the finished product	R80µm : 17%	R80µm : 14%
VCM Ventilation	98 Am3/s	98 Am3/s
VCM Feed	263,5 tph	280,4 tph
Grinding Pressure	163 bar	164 bar
Speed of the Classifier	1 746 rpm	1 766 rpm
Outlet temperature of the VCM	x	x
Height of the material bed	51 mm	56 mm
VCM Vibrations	1,84	1,91
VCM Delta P	x	x
Absorbed Power of the VCM (table)	2 401 kW	2 483 kW
kWh/t (table)	9,1kWh/t	8,9kWh/t
Absorbed Power of the fan	304 Amp	280 Amp
kWh/t (fan)	x	x
Height of the Dam Ring	80 mm	70 mm

Assessment of the installed dam ring (4)

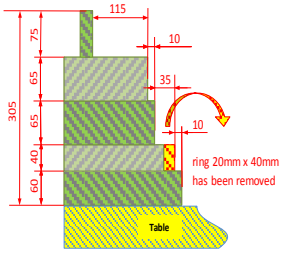
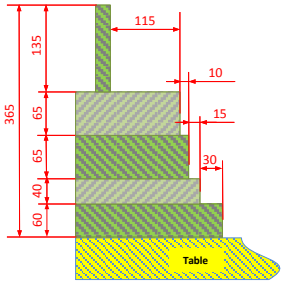
LM 46 2+2 - LOESCHE

- The figure below shows the drawing of the installed dam ring on the LOESCHE mills
- The dam ring is located at the edge of the table
- The total height of the dam ring is
  - 300mm on the LM46 2+2 – PECS plant – Hungary
  - 365mm on the LM46 2+2 – Saint-Pierre-La-Cour plant – France

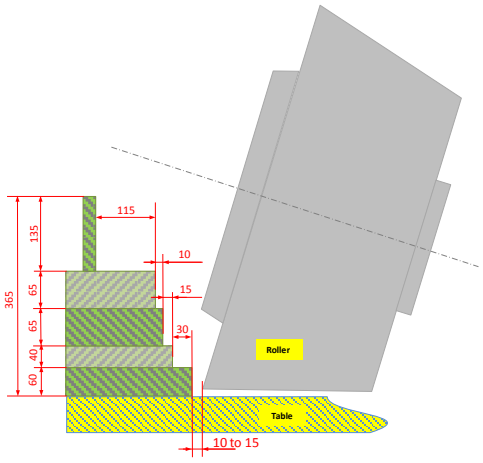


LM 46 2+2 – LOESCHE – Saint-Pierre-La-Cour

- On the LM46 2+2 VCM, trials were carried out on the steps to improve the mill's performances by optimizing the dam ring:
  - First action: removing a ring on the second stage of the dam ring. This action is supposed to improve the air draining during the compression of the bed of material. The compressed air is moving beside the compressed bed of material instead of flushing the material out of the bed.
  - Second action: increase by 60mm the height of the dam ring.

Action on the height of the Dam Ring	Drawing	From	To	Result
1) No Action on the height 2) Intermediate ring (H=40mm ; Thickness=20mm) removed on the second stage of the dam ring		305mm	305mm	1) higher production : 105,1tph versus 94,9tph (CEM II-B 32,5) 2) same absorbed power : 2MW 3) Lower mill DP : 39,7mbar versus 44,0mbar
Increase by 60mm		305mm	365mm	1) higher production : 115,0tph versus 105,1tph (CEM II-B 32,5) 2) Higher absorbed power at the table drive : 2,34MW versus 2MW 3) Higher mill DP : 44,1mbar versus 39,7mbar 4) lower S.E.

- The figure below shows the gap from the edge of the roller to the bottom part of the dam-ring.
  - The gap is 10mm to 15mm on the LM46.2+2 of SPLC

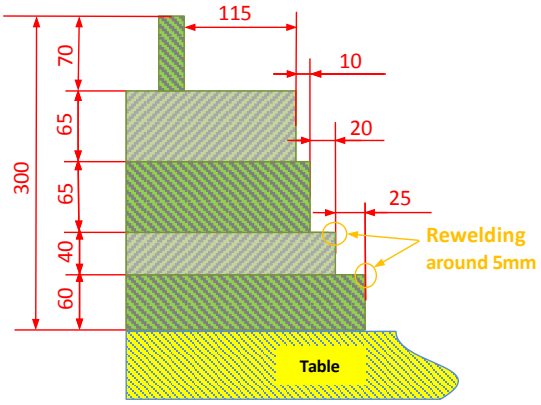


- The table below shows changes in the behaviour of the VCM installed at SPLC plant:
  - The dam ring height has been increased by 60mm.
  - In this case, a higher dam ring resulted in a better VCM stability, a higher production rate, and lower specific energy consumption.

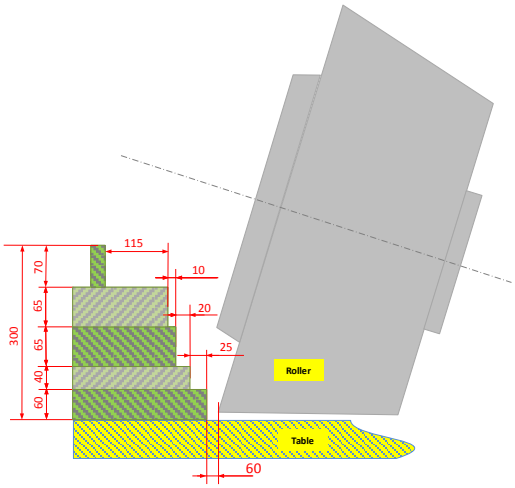
Main parameters	Before Modification	After Modification
Mill Supplier	LOESCHE	
Type of mill	LM46 2+2	
Plant - Country	Saint Pierre La Cour - France	
Product	CEM II/A-V 42,5 N PM-CP2	
Fineness of the finished product	4 960 cm²/g	5 020 cm²/g
VCM Ventilation	98 Am3/s	101 Am3/s
VCM Feed	94,9 tph	115,0 tph
Grinding Pressure	104 bar	104 bar
Speed of the Classifier	113 rpm	108 rpm
Outlet temperature of the VCM	93,7 °C	93,5 °C
Height of the material bed	53 mm	57 mm
VCM Vibrations	5,37	5,49
VCM Delta P	44,0 mbar	44,2 mbar
Absorbed Power of the VCM (table)	1 998 kW	2 340 kW
kWh/t (table)	21,1kWh/t	20,3kWh/t
Absorbed Power of the fan	743 kW	779 kW
kWh/t (fan)	7,8kWh/t	6,8kWh/t
Injected water	4 697 l/h	5 341 l/h
Injected water	49 l/t	46 l/t
Height of the Dam Ring	305 mm	365 mm

LM 46 2+2 – LOESCHE – Pecs

- The profile of the dam ring has not been changed since the commissioning.
  - Welding operation has been carried out to recover the initial profile.



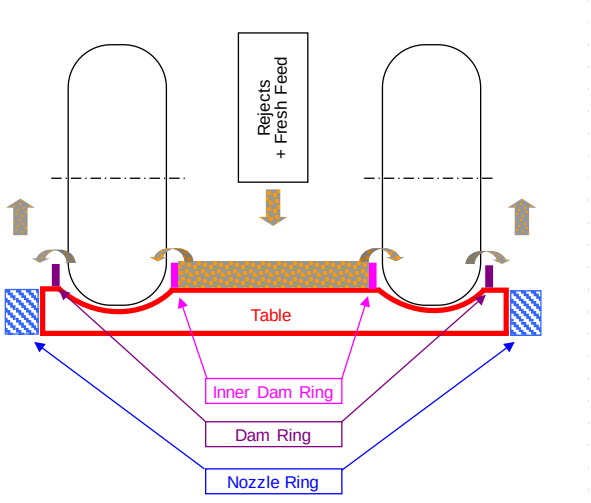
- The gap from the edge of roller and dam ring= 60mm
  - This gap (60mm) is higher than the gap of the LM46 2+2 installed at Saint-Pierre-La-Cour (10-15mm)



Assessment of the installed dam ring (5)

QUADROPOL - POLYSIUS

- The figure below shows the drawing of the installed dam rings on the QUADROPOL mills by POLYSIUS
- The external dam ring is located at the edge of the table
- The inner dam ring is located before the grinding track. It can be installed on Vertical Raw Mill or on a VCM.
  - The inner dam ring has been installed on a VCM : QMC² 40-20-230 (installed power = 2000kW) where the clinker is very fine (60% to 90% < 1mm)
  - A similar dam ring will be installed on the QUADROPOL with Roller Drive concept.

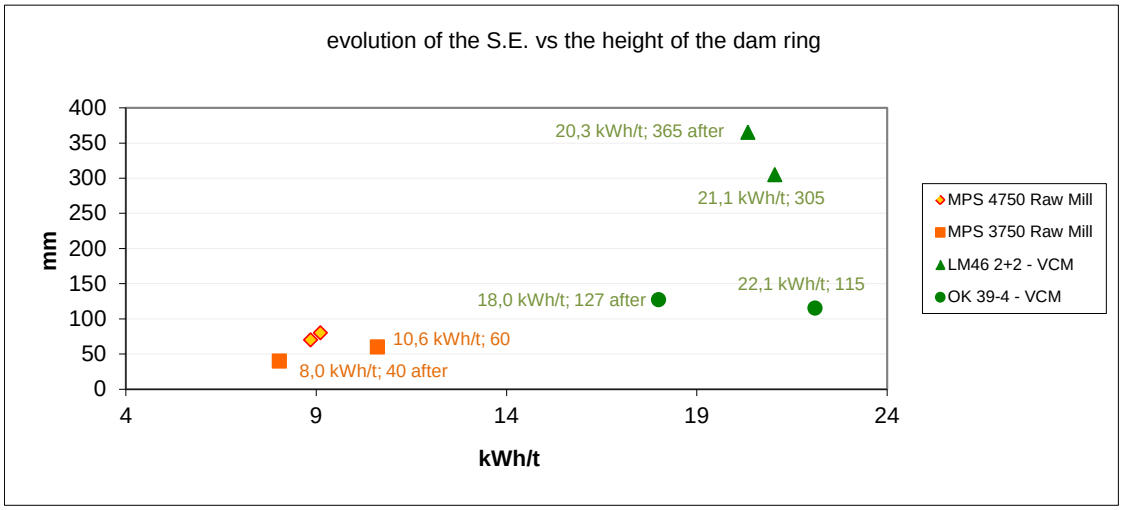


How to adjust the dam ring of a vertical mill

The dam ring is a key equipment for optimising the vertical mill

- The main function of the dam ring is to keep the material on the table in order to grind the material under the rollers.
- The adjustment of the height of the dam ring will impact:
  - the height of the material bed
  - the absorbed power
  - the mill vibrations
  - the specific energy (grinding efficiency).

- The figure below shows the evolution of the S.E. versus the height of the dam ring.
  In this case, for these four mills:
  1) a reduction of the height of the dam ring on the Vertical Raw Mill gave better performances;
  2) an increase of the height of the dam ring on the Vertical Cement Mill gave better performances.



- The table below is a summary of variations in the dam ring of the mills studied.

MPS 4750 Raw Mill	before	after
kWh/t	9,1	8,9
mm	80	70
MPS 3750 Raw Mill	before	after
kWh/t	10,6	8,0
mm	60	40
LM46 2+2 - VCM	before	after
kWh/t	21,1	20,3
mm	305	365
OK 39-4 - VCM	before	after
kWh/t	22,1	18,0
mm	115	127

Preliminary steps before modifying the dam ring

- The next chart shows the preliminary steps to follow before modifying the dam ring.

How to adjust the dam ring of a vertical mill