EnFloTech

The Enflotech Group of Companies

The Split Loading Frame for Pendulum Type Roller Mills

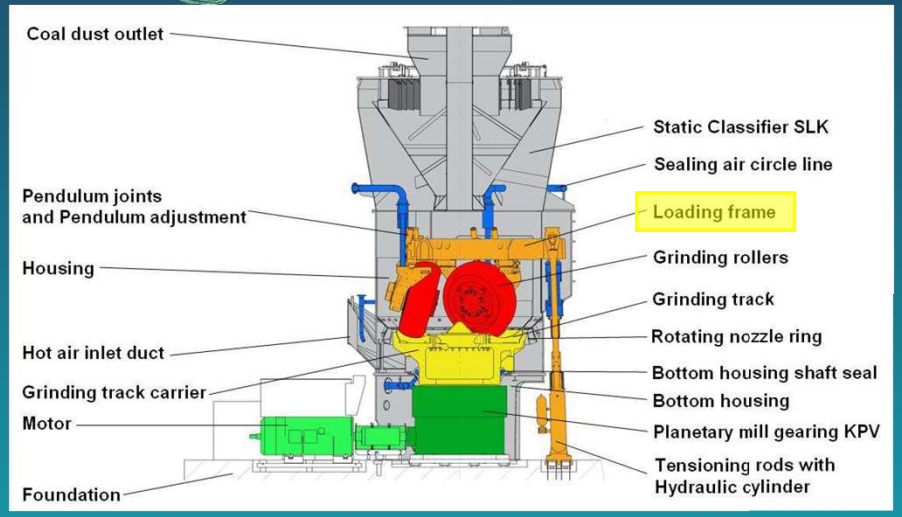


Committed to SA's energy.

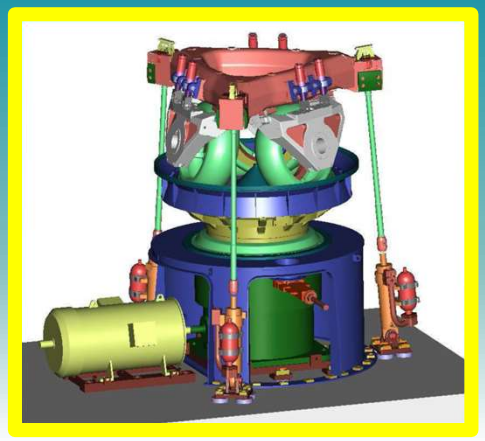
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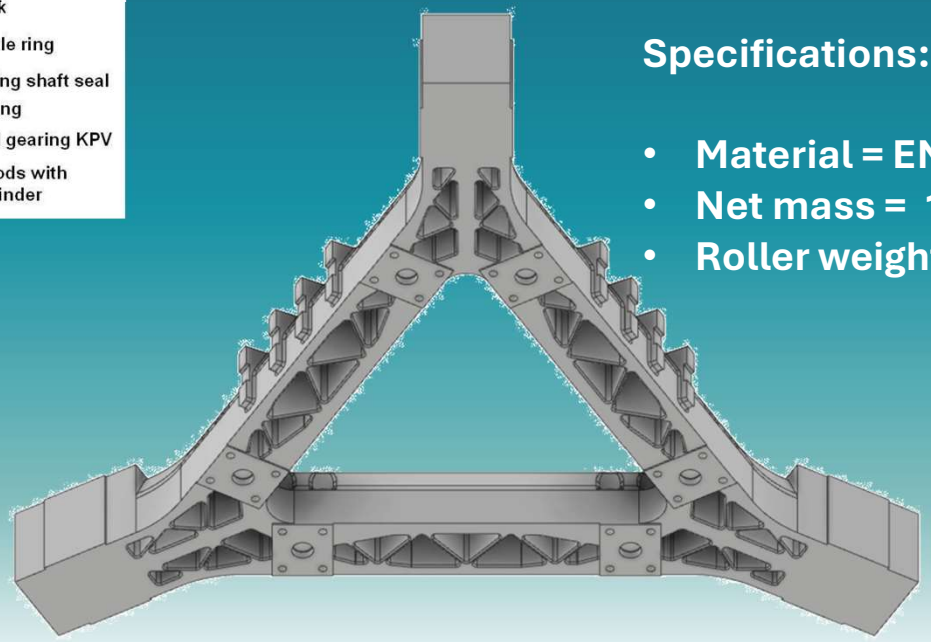
Mill Loading Frame

Design Base Plant Introduction



- Medupi and Kusile power stations are fitted with the MPS 265 non contact vertical spindle mills (60 mills and 8.64 GW of sent out capacity in South Africa)
- Central to the mill loading system is the mechanism to transfer potential hydraulic energy into mechanical grinding energy – the structure known as the loading frame



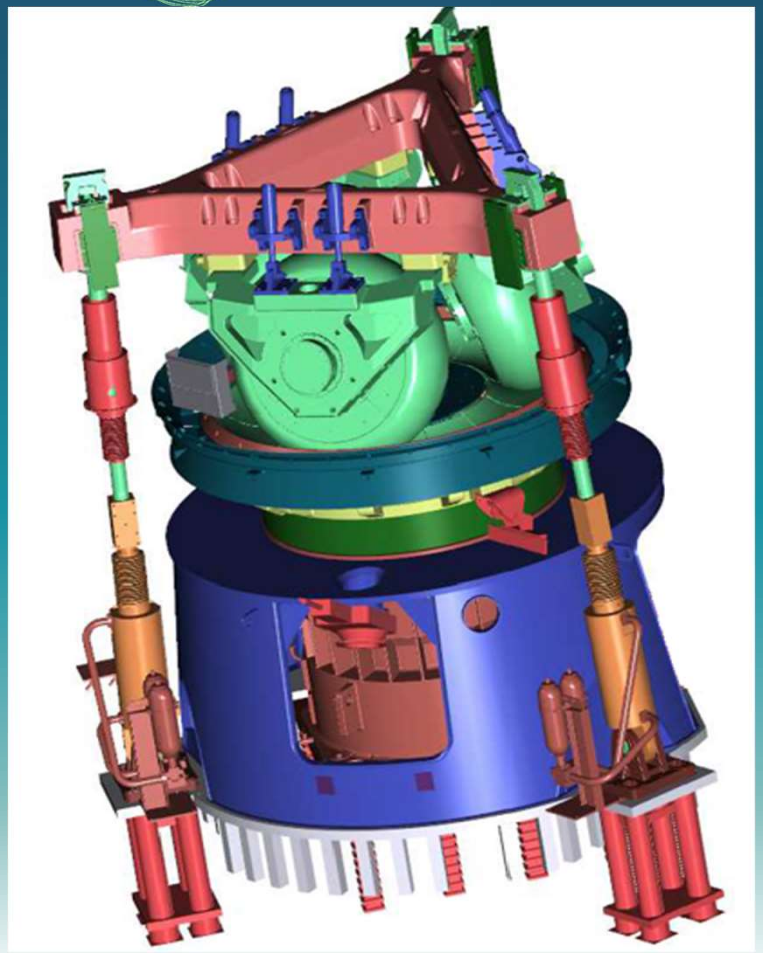


Specifications:

- **Material = EN-GJS-400-15 (GGG-40)**
- **Net mass = 11 934 kg**
- **Roller weight = 49 497 kg (3 rollers)**

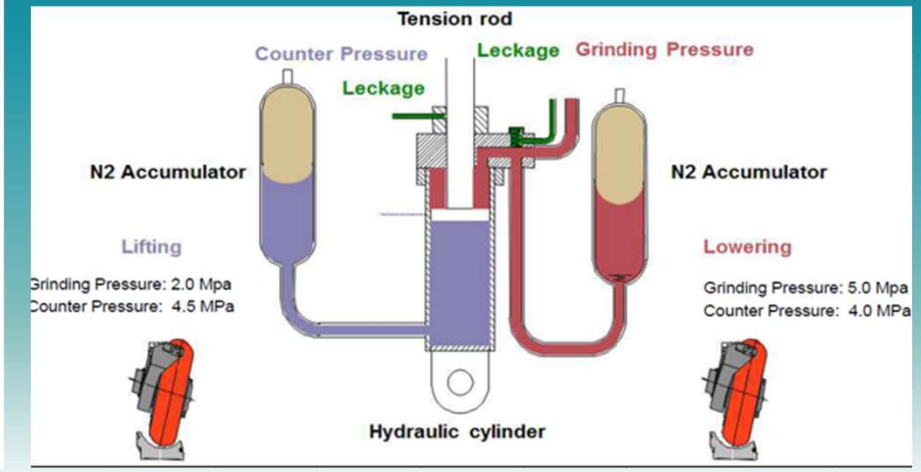
Mill Loading Frame

Design Base Plant Introduction and Loads



Hydraulic forces:

- Worst case scenario 100% mill throughput (114.2 t/hr) with maximum specific grinding force of 750 kN/m^2 (mills normally run between 320 and 400 kN/m^2)
- Counter force= 265 kN per cylinder
- Grinding force = 1124 kN per cylinder
- Resultant applied force = 860 kN per cylinder
- Abnormal operation and fatigue taken in to account with assumptions for simplification of 3D loads

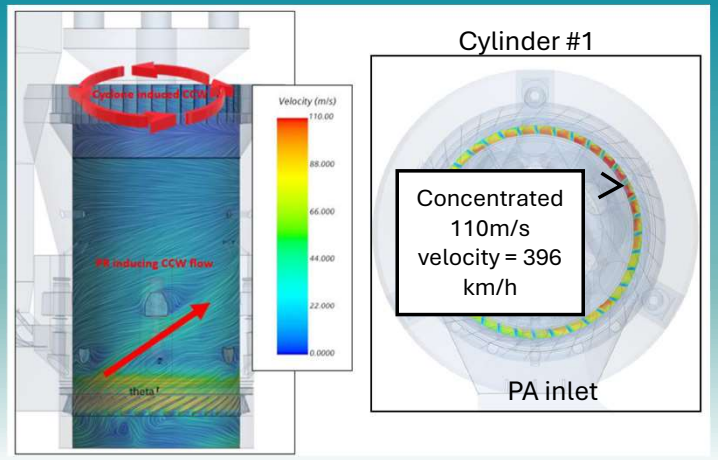


Mill Loading Frame

Design Base Plant Challenges

Cause

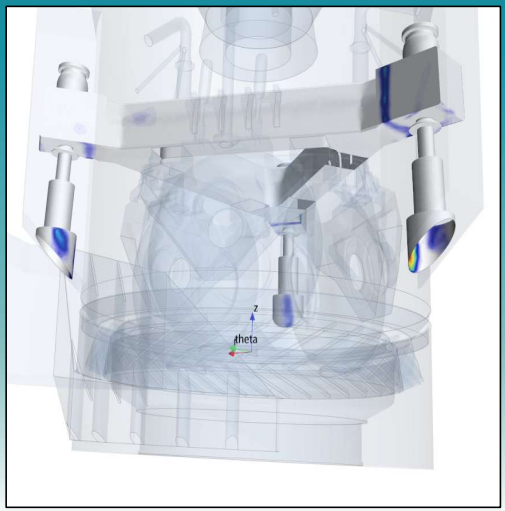
- The fan effect of the existing nozzle ring design does not effectively distribute the PA evenly around the mill grinding zone resulting in PA velocities of close to 110 m/s (396 km/h) and particles impacting the loading frame at cylinder 1 and 2 area. Wear protection has been applied. Legacy damage remains
- Mill fires in the grinding zone causing loading frame damage (wet fine coal, hot air isolation challenges)



Effect

- The result was the loading frame getting bombarded by high velocity abrasive PF causing loss of structural material (still remaining from before wear protection)
- Post fire visuals and NDT revealed compromised structural integrity with crack propagation evident
- Risk of catastrophic failures and need for selected loading frame replacements to mitigate risks



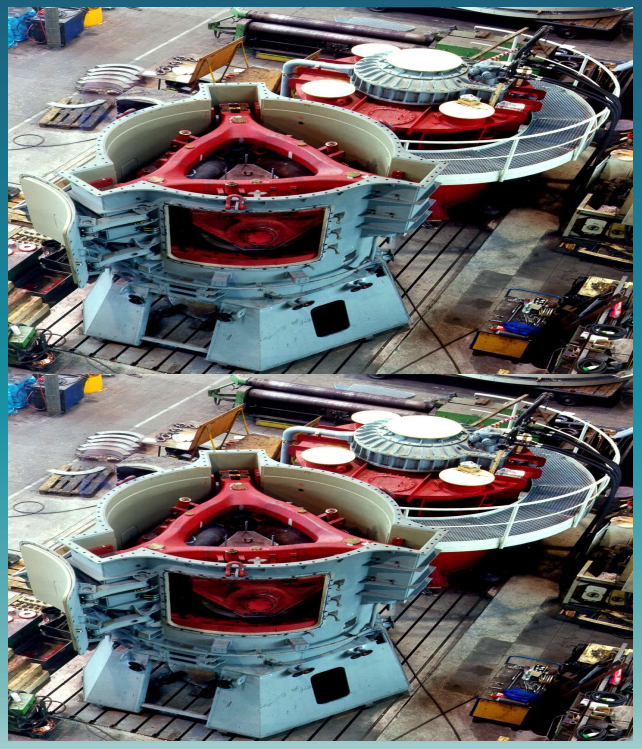


Mill Loading Frame

Design Base Plant Challenges

The Challenges Relating to Loading Frame Replacement

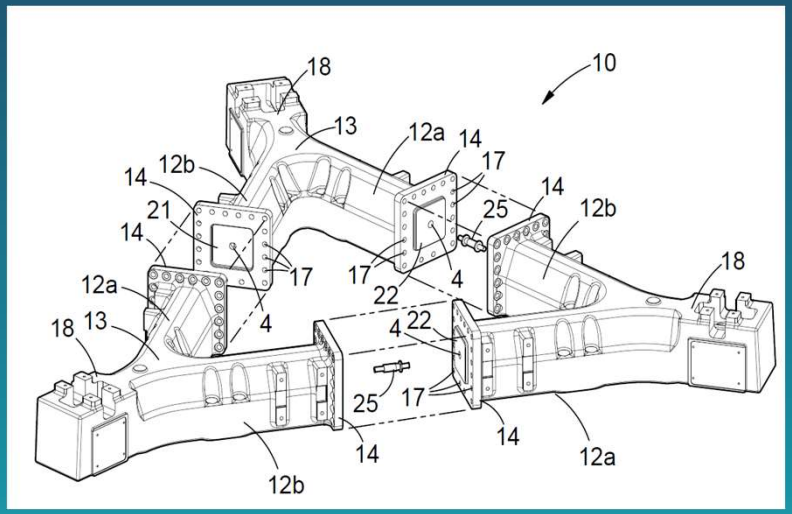
- The mill ergonomics is such that the design of the loading frame and mill carrier is for life of plant (non-wearing part)
- Removal of the mill classifier is possible but it requires extensive work that can take 3 months or more and it results in the unavailability of the spare mill for an extensive period of time
- The size of the loading frame is such that it cannot be replaced through the mill maintenance/service door



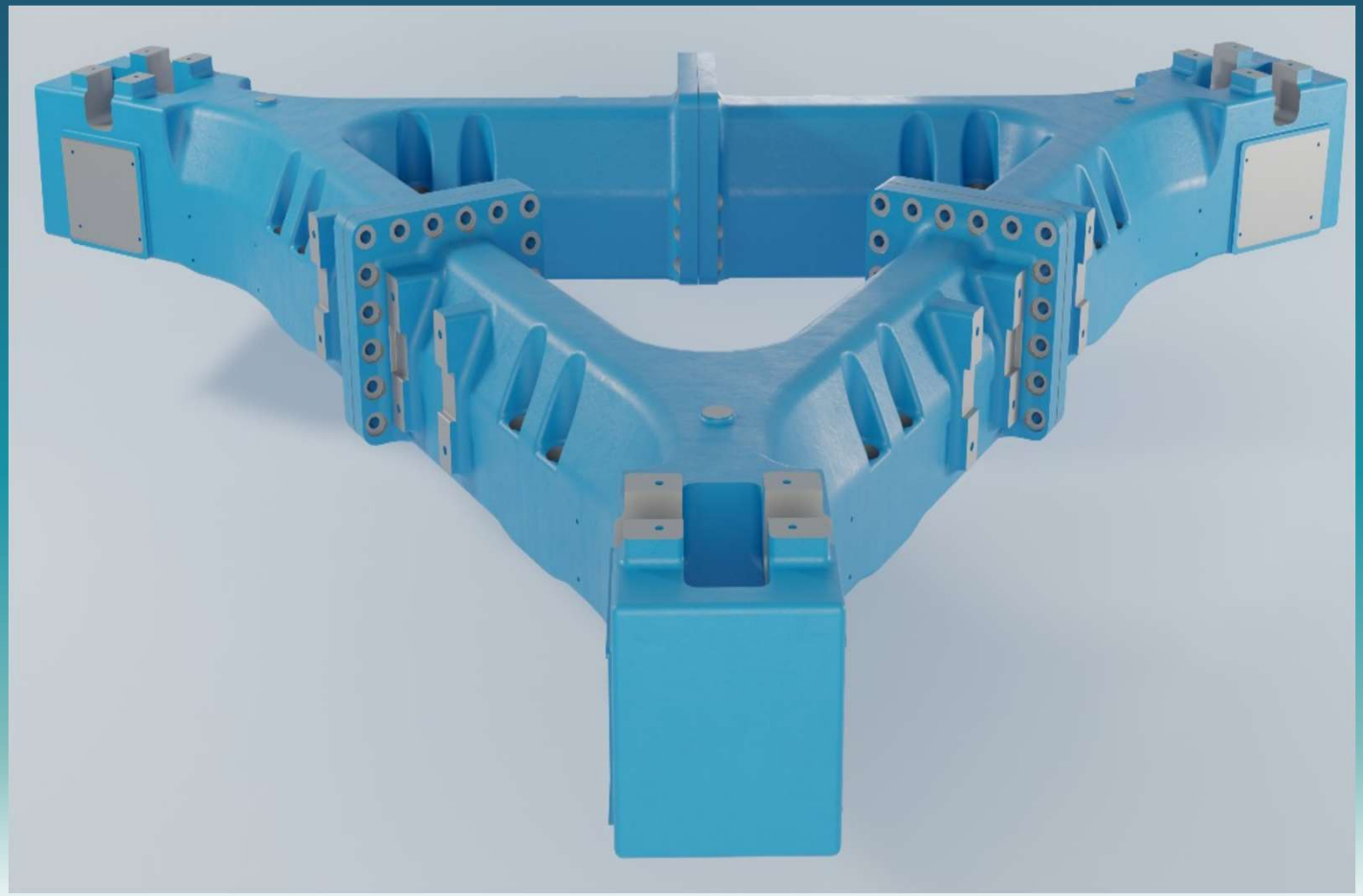


The Split Loading Frame (Patented)

Introduction







Installed in less than a week



Through the conventional mill maintenance/service door



The Split Loading Frame (Patented)

Design Methodology

1) Evaluated mechanical properties of the original casting material
2) Desktop study done to determine whether to fabricate the loading frame using steel (joining through welding and fasteners) or to cast in steel or ductile iron
3) Establish the load scenarios:

   a) Normal operating conditions for full Unit load with the application of typical component failure scenarios and the inclusion of fatigue

   b) Maximum mill load condition and maximum grinding force with the application of typical component failure scenarios and the inclusion of fatigue

   c) 3D model simplified in terms of camber, toe in and loading cylinder angle to the vertical

   d) Decision of where to put the joints finalised based on load and stress analysis

The Split Loading Frame (Patented)

Design Methodology

4) Isolated analysis of joint scenarios to determine whether a joint was possible using material yield as the failure point for original loading frame. The design target was equivalent or better
5) Analysis of alternative ductile iron materials done due to limitations related to joint spot face yielding (SG50)
6) Analysis of original loading frame in FEM to determine the stresses and safety factors based on the defined load scenarios. High stress areas optimised as necessary
7) Analyse the split loading frame in FEM to determine the stresses and safety factors based on the defined load scenarios. High stress areas optimised as necessary
8) An 18 bolt joint design chosen over a 20 and 17 bolt joint design based on grinding tyre space constraints and joint face spot facing yielding concern as original material was chosen based on best ductility. The final design achieved equal or better safety factors for bending about the horizontal axis but only 89% of the safety factors about the vertical axis which was accepted as an acceptable compromise
9) Detail design done for spigot, fasteners, washers, machining surface roughness, tolerances and wear protection

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The Split Loading Frame (Patented)

Design: Material Evaluation and Selection

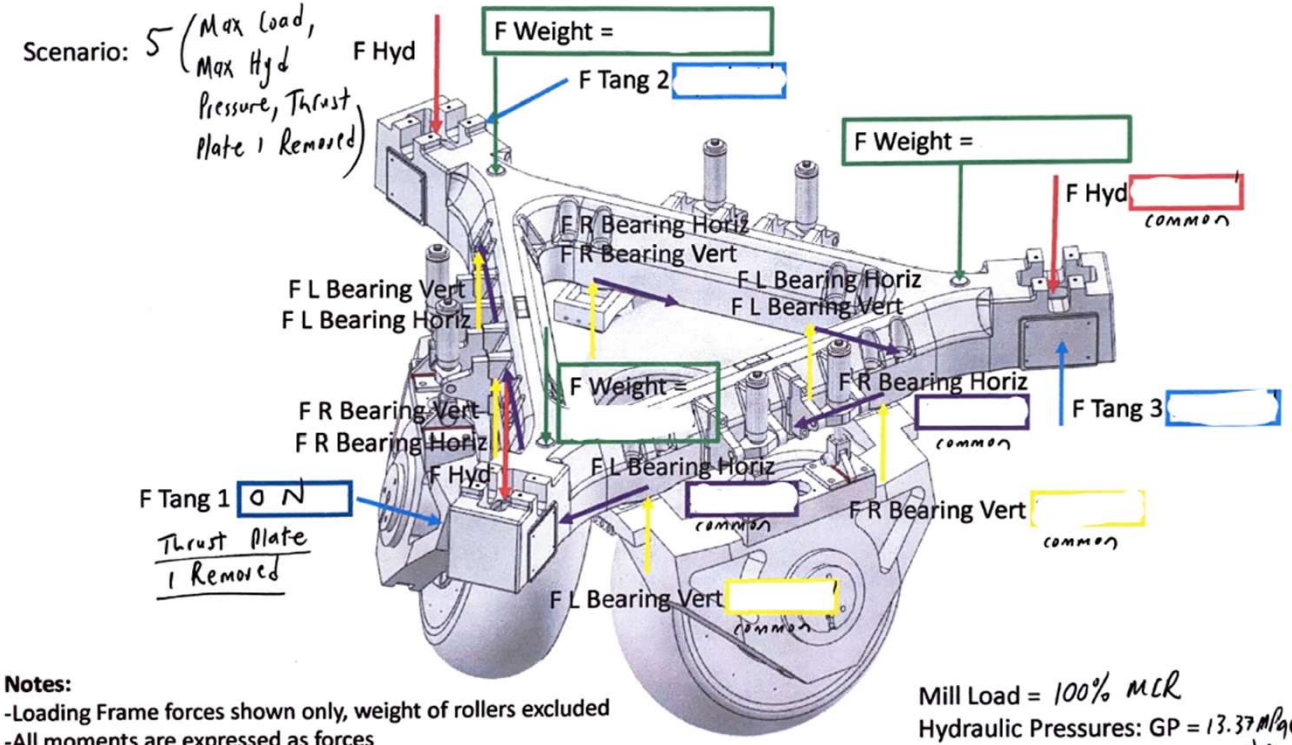
SG (DUCTILE) IRONS

A comprehensive range of S.G. Irons is offered to international specifications for engineering applications.

OZZ Grade	Equivalent Specifications		Mechanical Properties				Microstructure
			Yield (MPa)	U.T.S. (MPa)	% Elong.	BHN	
750	ASTM A536 Gr 60-40-18 BS 2789 Gr 400/18	DIN 1693 Gr GGG40 SABS 936 Gr SG38	245	375	18	180	Ferritic
751	ASTM A536 Gr 65-45-12 BS 2789 Gr 420/12	SABS 936 Gr SG42	275	420	12	200	
752	ASTM A536 Gr 80-55-06 BS 2789 Gr 500/7	DIN 1693 Gr GGG50 SABS 936 Gr SG50	310	500	7	170-241	Pearlitic / Ferritic
753	ASTM A536 Gr 80-55-06 BS 2789 Gr 600/3	DIN 1693 Gr GGG60 SABS 936 Gr SG60	350	600	3	192-269	
754	ASTM A536 Gr 100-70-03 BS 2789 Gr 700/2	DIN 1693 Gr GGG70 SABS 936 Gr SG70	400	700	2	229-302	Pearlitic
755	ASTM A536 Gr 120-90-02 BS 2789 Gr 800/2	DIN 1693 Gr GGG80 SABS 936 Gr SG80	460	800	2	248-352	
763	ASTM A123 Gr 850/550/10		550	850	10	269-321	Austempered Ductile Iron

The Split Loading Frame (Patented)

Design: Determine the Load Cases



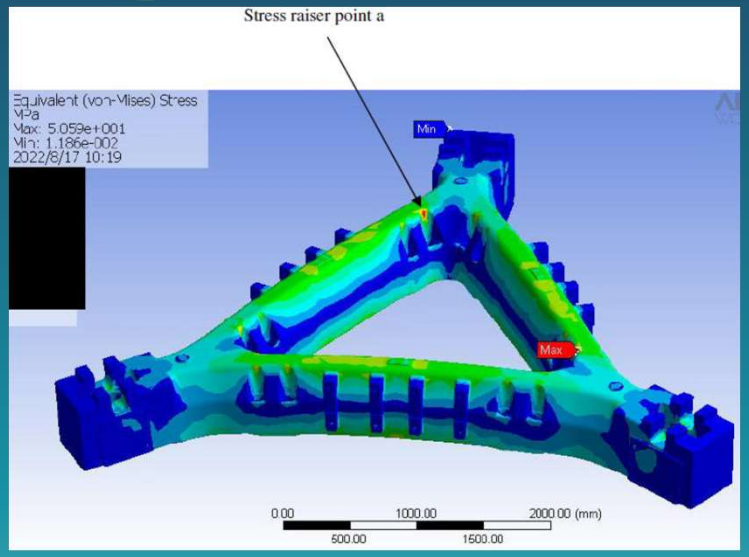
Notes:
- -Loading Frame forces shown only, weight of rollers excluded
- -All moments are expressed as forces
- -F Hyd and F Weight respective magnitudes are equal on the three points shown
- -All Bearing Horizontal forces (x 6) are assumed equal in magnitude

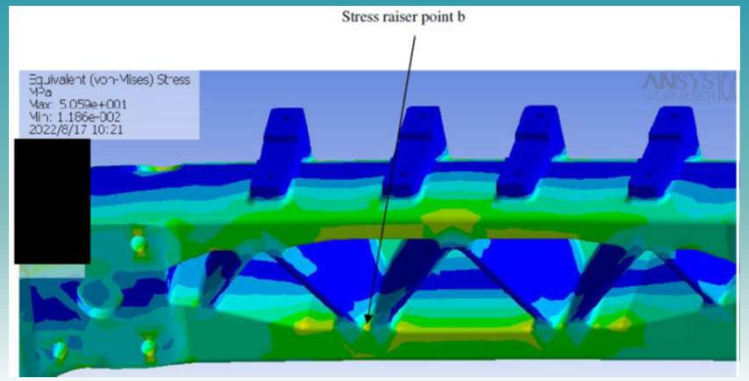
Mill Load = 100% MCR
Hydraulic Pressures: GP = 13.37 MPa CP = 2.6 MPa
Thrust Plates in contact = TP1 ☒ TP2 ☑ TP3 ☑

Load case description
Scenario 1: 78% mill load (normal load, normal operation)
Scenario 2: 78% mill load, one thrust plate not in contact (normal load, abnormal operation)
Scenario 4: 100% mill load (maximum mill load, maximum grinding force, normal operation)
Scenario 5: 100% mill load, one thrust plate not in contact (maximum mill load, maximum grinding force, abnormal operation)
Scenario 6: 100% mill load, one roller hanging (maximum mill load, maximum grinding force, abnormal operation on cylinders)
Scenario 7: 100% mill load, two rollers hanging (maximum mill load, maximum grinding force, abnormal operation on cylinders)
Scenario 8: Lifting of rollers (normal, maintenance safety)

The Split Loading Frame (Patented)

Design: FEM of OEM Loading Frame





Load case description	Safety factor against overload	Fatigue safety factor at stress raiser 'a'	Fatigue safety factor at stress raiser 'b'
Scenario 1	6.1	3.9	4.5
Scenario 2	5.8	3.7	4.6
Scenario 4	2.3	1.6	1.7
Scenario 5	2.2	1.5	1.8
Scenario 6	2.9	2.0	2.2
Scenario 7	4.5	2.9	3.3
Scenario 8	10.4	7.3	7.6

*** Note the safety factor against static overload is in the area of the proposed joint on original loading frame**

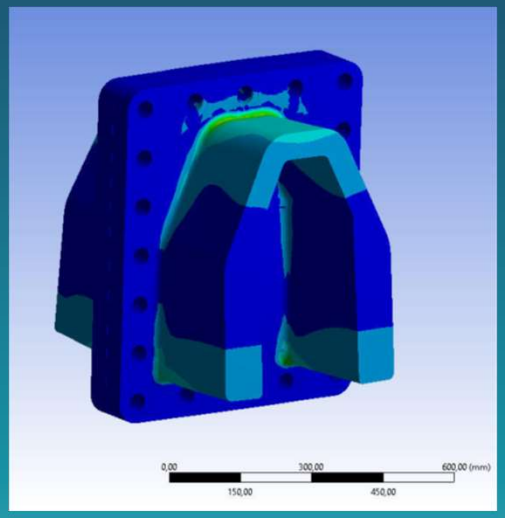
The Split Loading Frame (Patented)

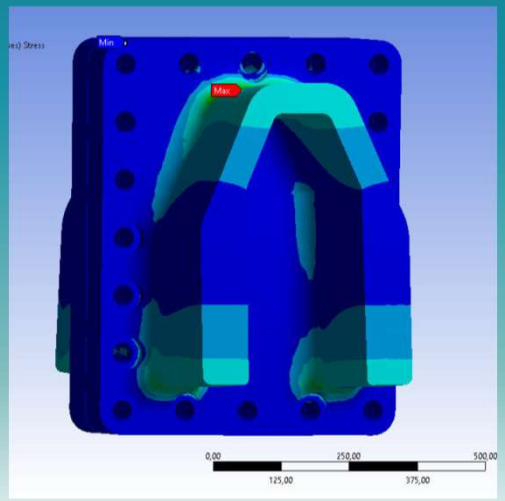
Design: Joint Design

Target bending moment capabilities of the bolted connection

Static loading		
	About horizontal neutral axis	About vertical neutral axis
Bending moment at onset of yield	1980 kNm ✓	2290 kNm ✗ 2040/80%

Operational loads		
	About horizontal neutral axis	About vertical neutral axis (joint is at inflection point)
Bending moment at position of bolted joint	590 kNm	0 kNm



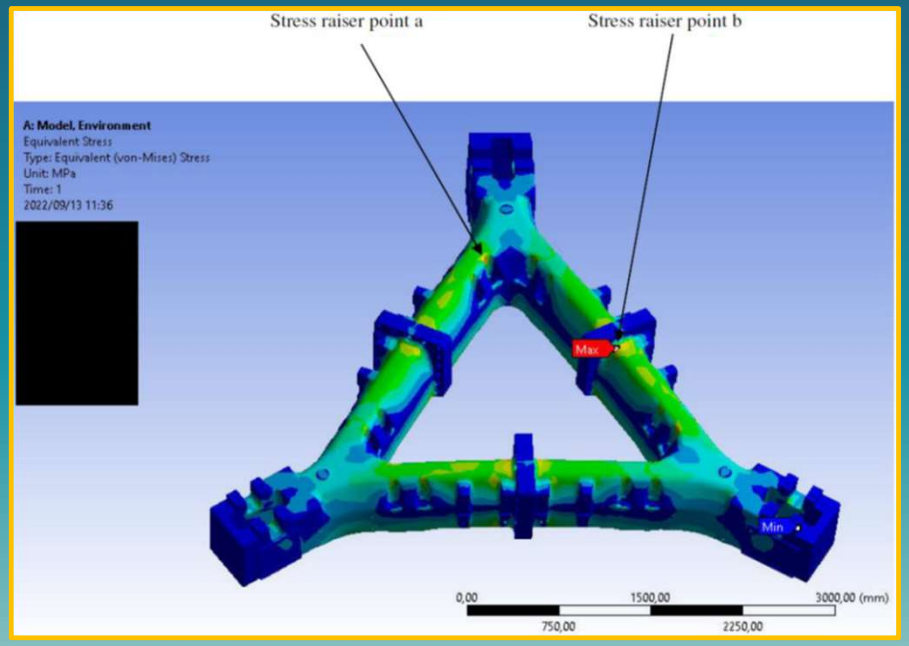


Safety factors comparison between the bolted joint and original beam resulting from operational loads

Original Frame		Bolt Pattern		
		Static		Fatigue Failure
Static overload	Fatigue Failure	Bolt Overload	Joint Separation	Bolt Overload
2.8	2.1	5.3	2.8	8.5

The Split Loading Frame (Patented)

Design: FEM of the Split Loading Frame



Load case description	One-piece design		Split design -17-bolt design			Split design -18-bolt design		
	Safety factor against static overload J	Safety factor against fatigue 'a'	Safety factor against static overload J	Safety factor against fatigue (as cast surface) b	Safety factor against fatigue (Machined surface) b'	Safety factor against static overload J	Safety factor against fatigue (as cast surface) b	Safety factor against fatigue (machine surface) b'
Scenario 1	6.1	3.9	6.1	4.0	4.5			
Scenario 2	5.8	3.7	5.8	4.0	4.5			
Scenario 4	2.3	1.6	2.3	1.5	1.7	2.2	2.0	2.2
Scenario 5	2.2	1.5	2.2	1.5	1.7			
Scenario 6	2.9	2.0	2.9	1.9	2.2			
Scenario 7	4.5	2.9	4.5	2.8	3.2			
Scenario 8	10.4		10.4			9.5		

The Split Loading Frame (Patented)

Medupi Power Station – Split Loading Frame

With design complete, fabrication could commence:

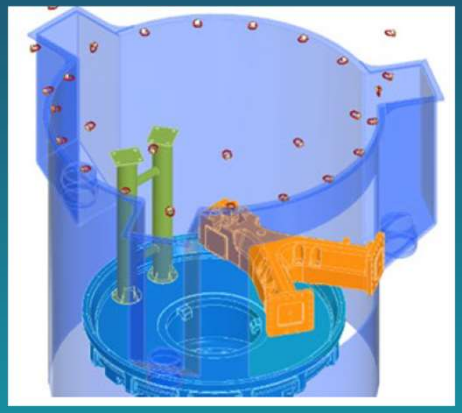
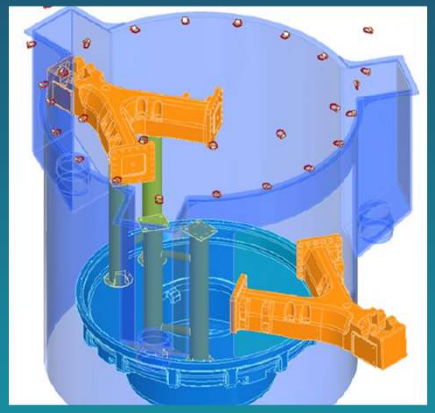
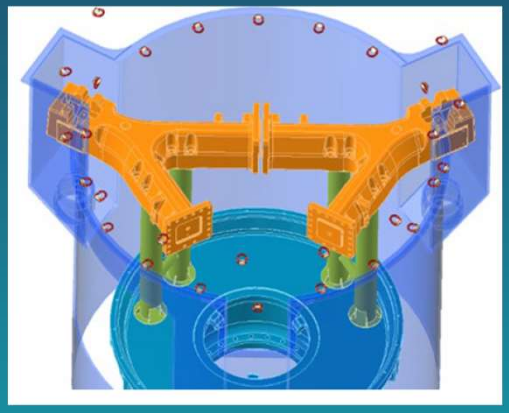
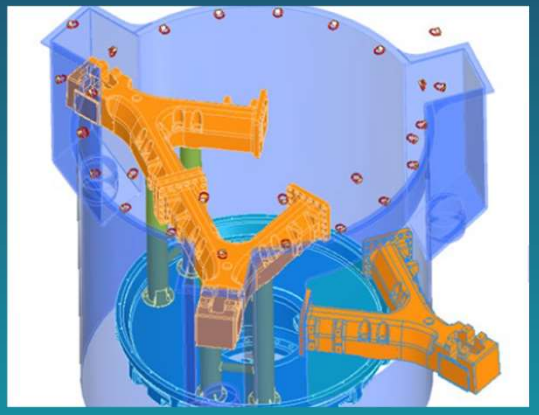
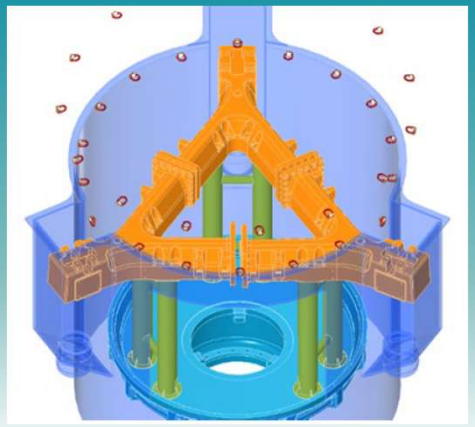
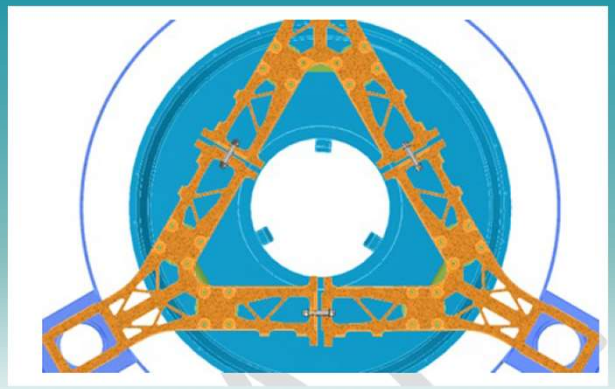
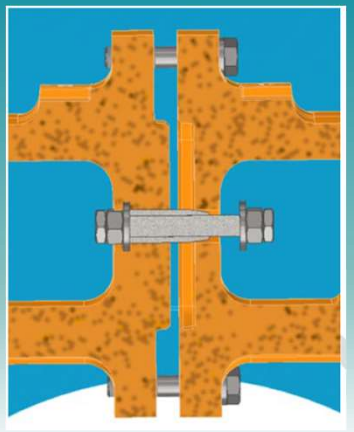
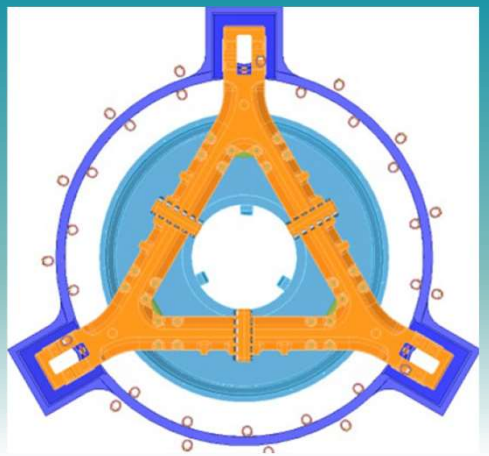




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The Split Loading Frame (Patented)

Installation Study

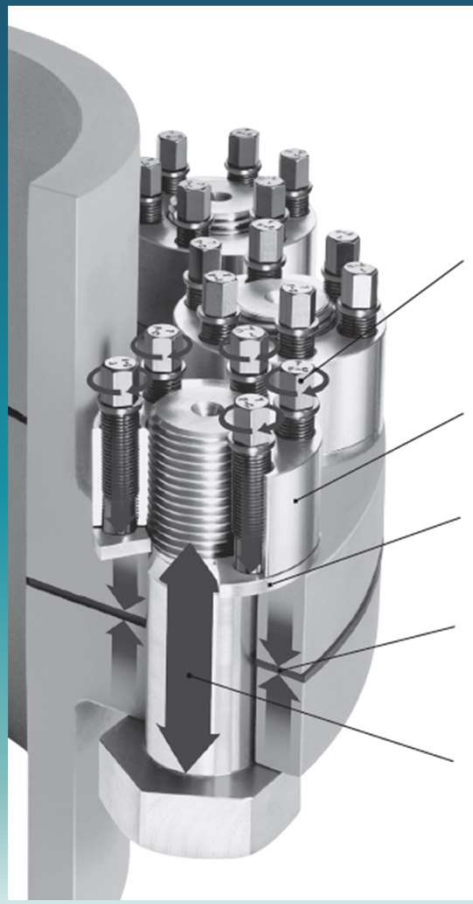









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The Split Loading Frame (Patented)

Interesting Information on the Bolted Connections





How Superbolt tensioners work:

By turning the jackbolts, a strong thrust force is generated and directed against a hardened washer. The jackbolts have a small friction diameter creating a high thrust force for relatively little torque.

The loads are transfered through the nut body which is positioned on the main thread by hand.

A hardened washer is used to transfer the force while protecting the flange face and nut body.

The thrust force of many jackbolts and the opposite reaction force of the main bolt head create a strong clamping force on the flange.

The thrust (axial) force from the jackbolt creates an equally strong reaction force in the main bolt.

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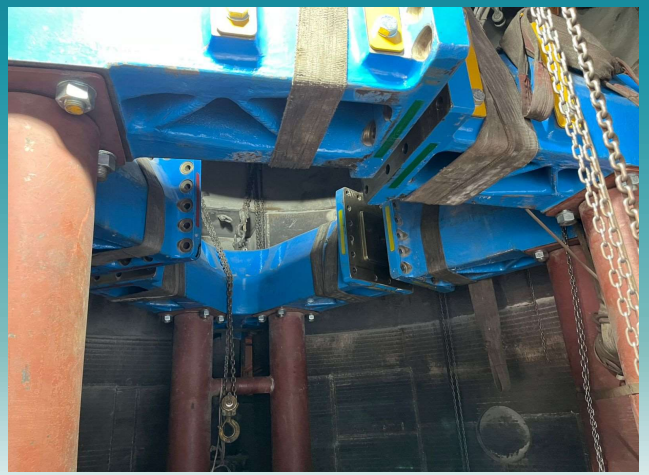
The Split Loading Frame (Patented)

Pictures Medupi Mill 4-10 Installation







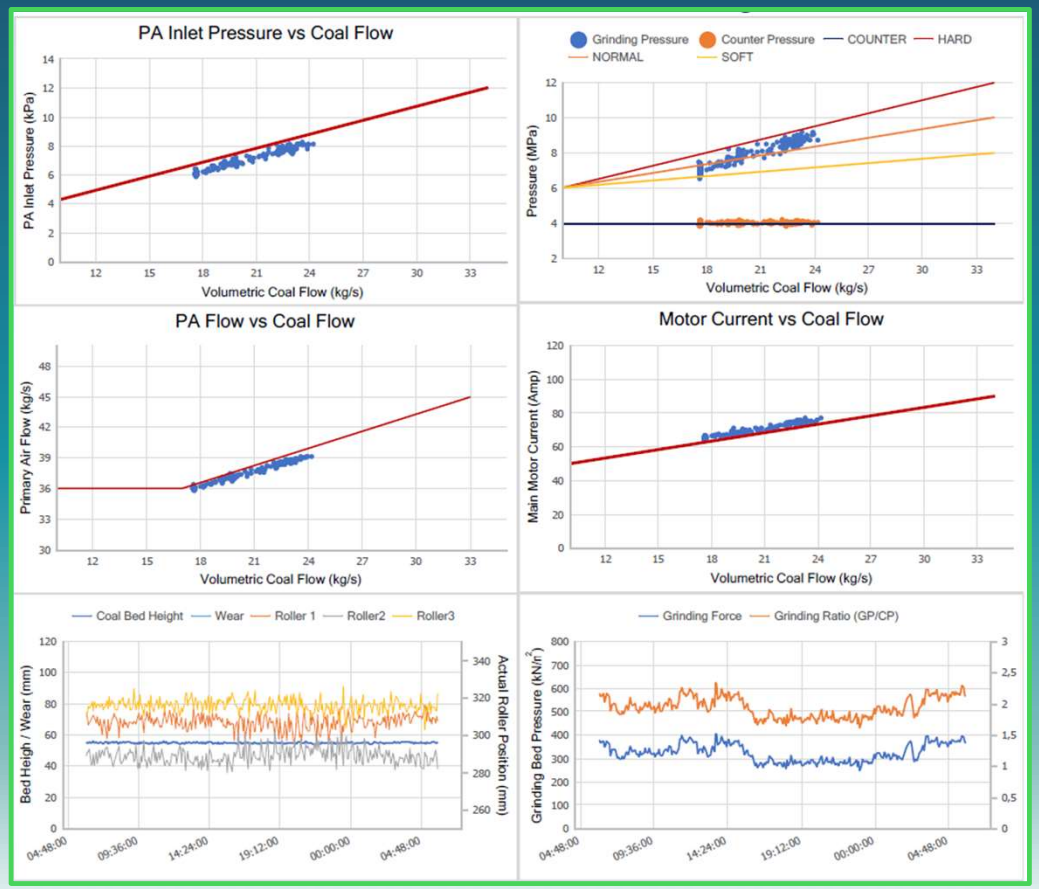




AI Mill Monitoring and Training (Claude)

Medupi Mill 4-10

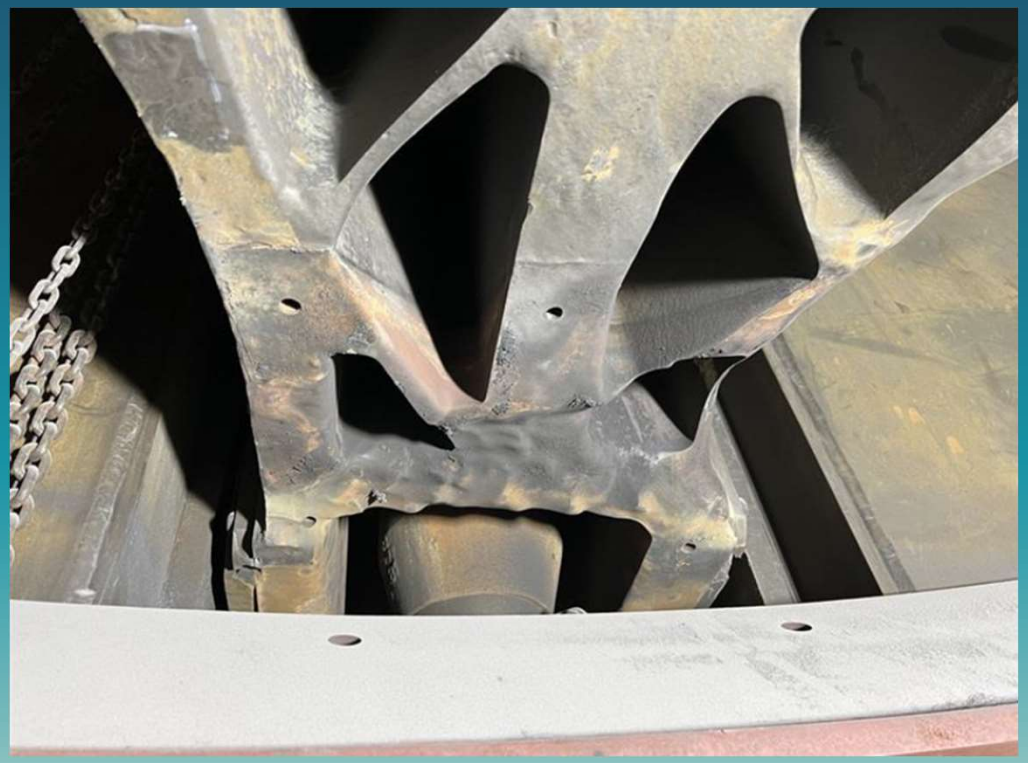
Running Hours: 1988



- Some work has been done to feed Medupi mill performance reports to Claude and train Claude to analyse them
- Claude is able to analyse them with the instructions given but also link events and changes to process variables and draw valuable conclusions from the data
- Claude can successfully inform you when maintenance and inspections are due what must be done when and to what specification
- The installation can indirectly be monitored with the available data and warn of a problem at the click of a button
- Poor data can be detected and related to common cause (server issue) rather than warning you of a problem that does not exist on the mill

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Questions?





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