



SAG MILLS OPTIMIZATION: IMPLEMENTATION AND EVALUATION IN DOÑA INÉS DE COLLAHUASI MINING

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CMDI de Collahuasi – Lmagne Ingeniería

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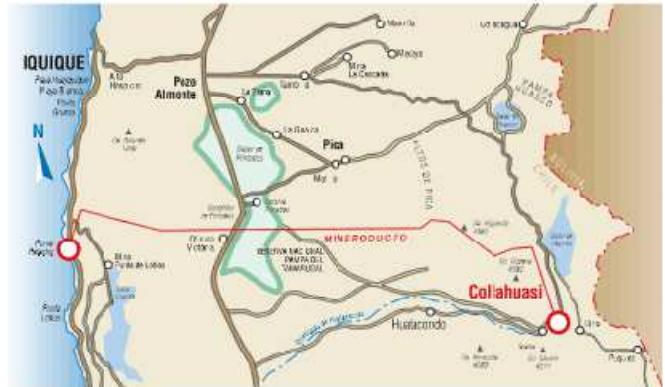
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Compañía Minera Doña Inés de Collahuasi



Is located 4.400 meters above sea level in the Andean plateau of the Tarapacá Region of the far north of Chile, to 245 km from Iquique.



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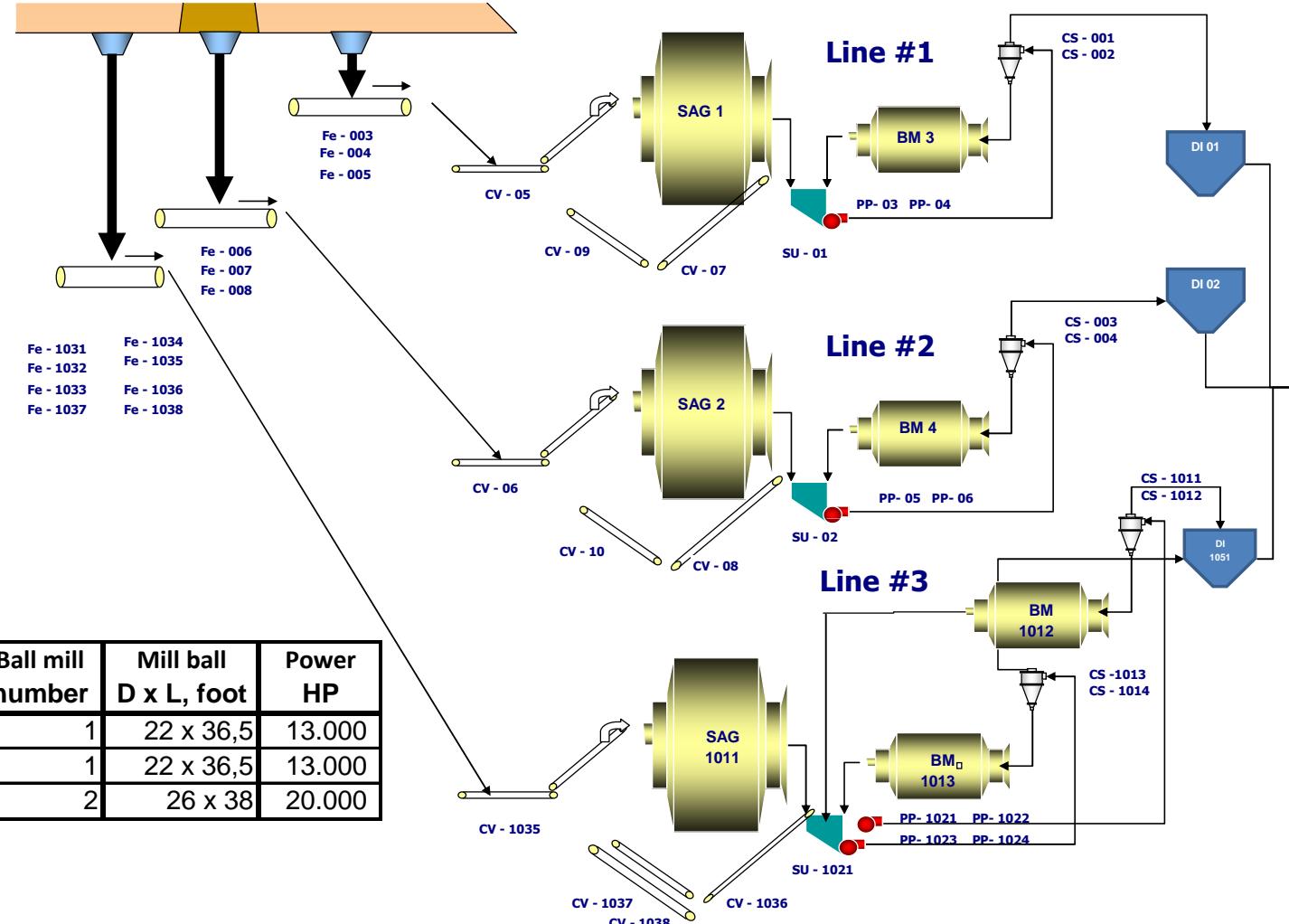


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Semiautogenous Grinding Circuit



Line	SAG D x L, foot	Power HP	Ball mill number	Mill ball D x L, foot	Power HP
1	32 x 15	11.000	1	22 x 36,5	13.000
2	32 x 15	11.000	1	22 x 36,5	13.000
1011	40 x 24	28.000	2	26 x 38	20.000

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Semiautogenous Mill Optimization

Trommel:

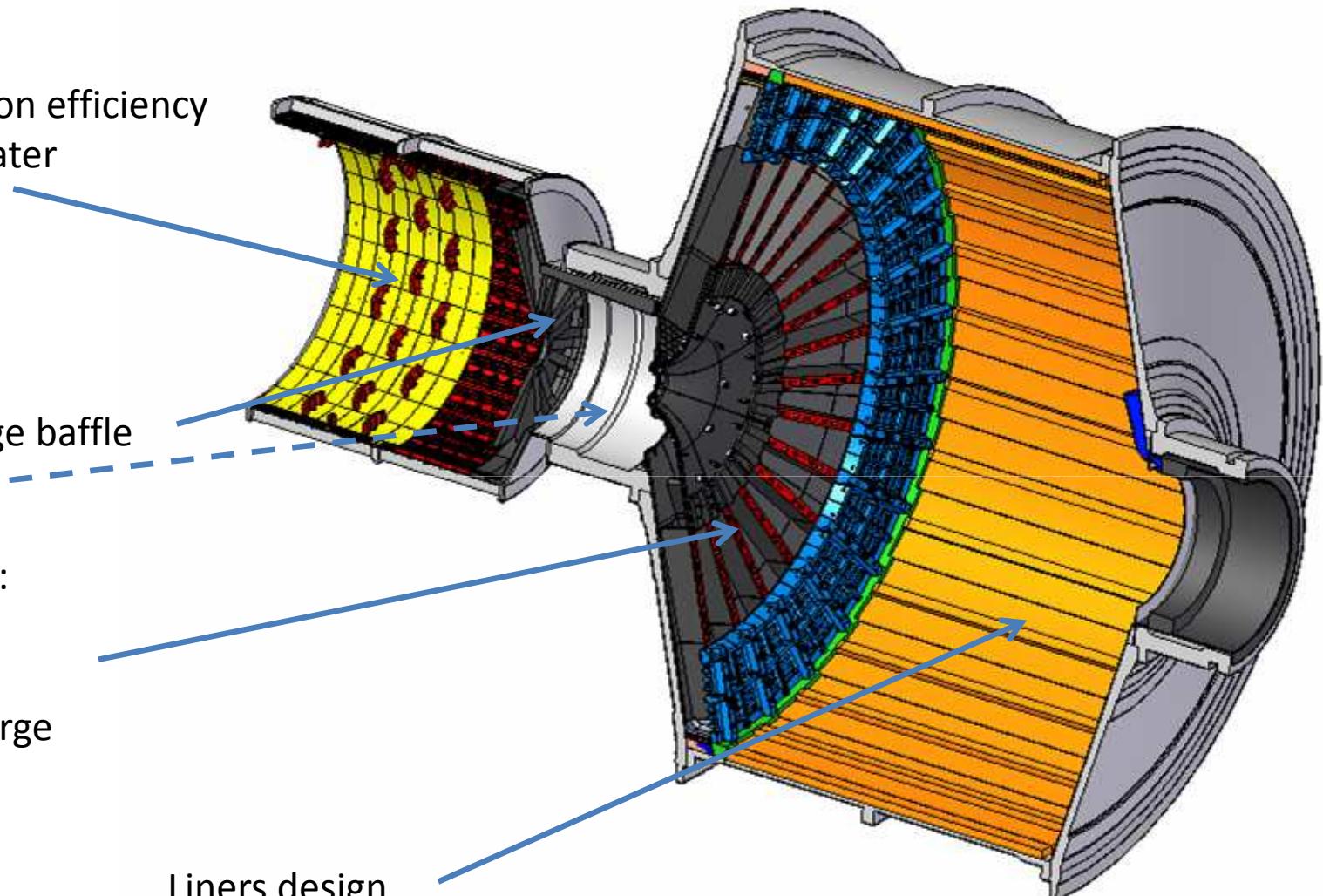
- classification efficiency
- laundry water

SAG 1011: Charge baffle
in trunnion

End discharge:

- Grates
- Pulp lifters
- Cone discharge

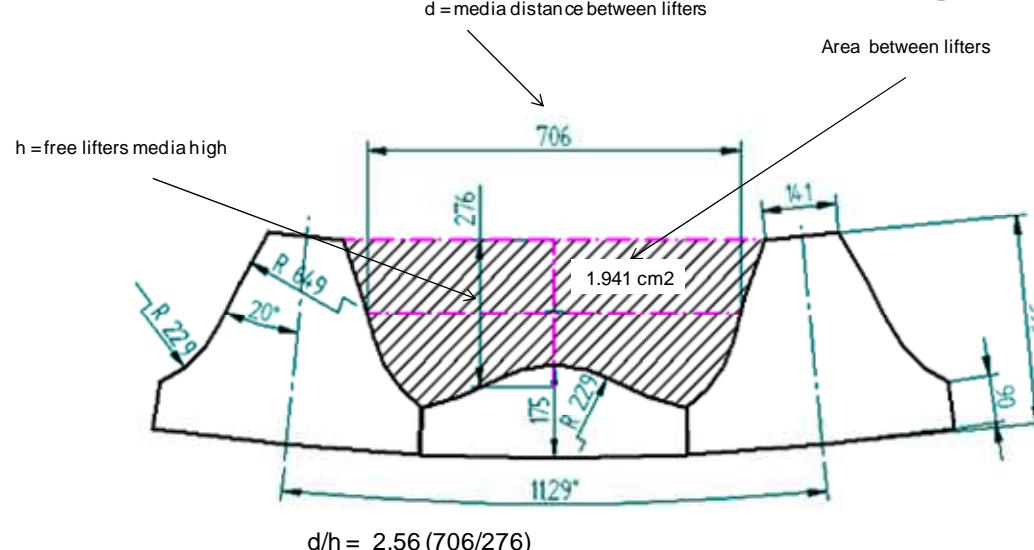
Liners design



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SAG Mills Linings Design

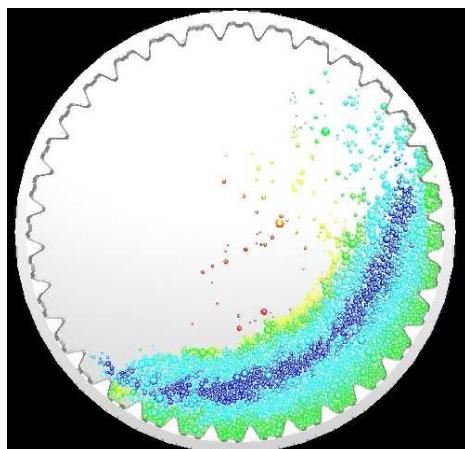
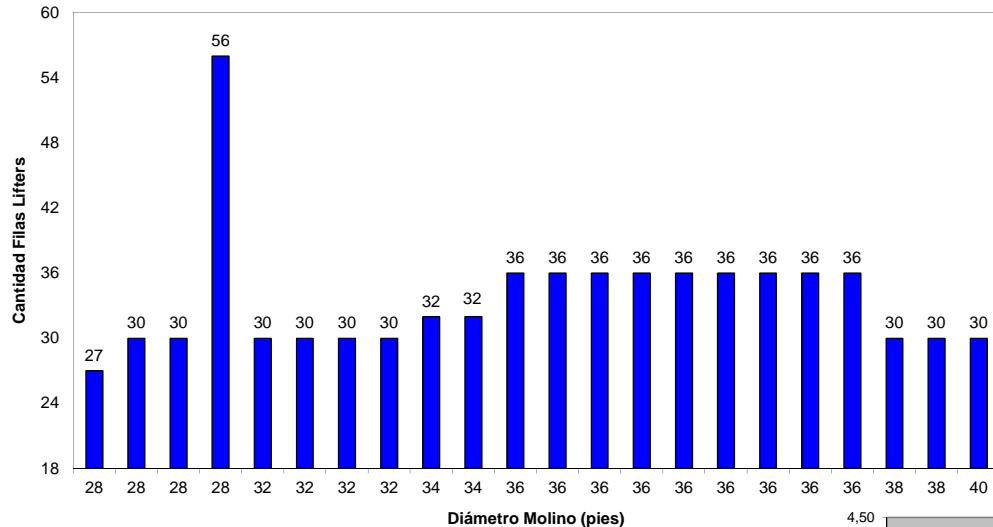


- d/h : it relates liners distance and media box high between lifters
- V_{lift}/V_{mill} : it relates volume between liners and mill volume
- Lifting angle: is the attack lifter's angle (one or more)
- Using MillMED simulations is calculated the effect over:
 - Useful impacts (Ball-Ore, Ore-Ore, Ore-Liners)
 - Useless impacts (Ball-Ball, Ball-Liners)

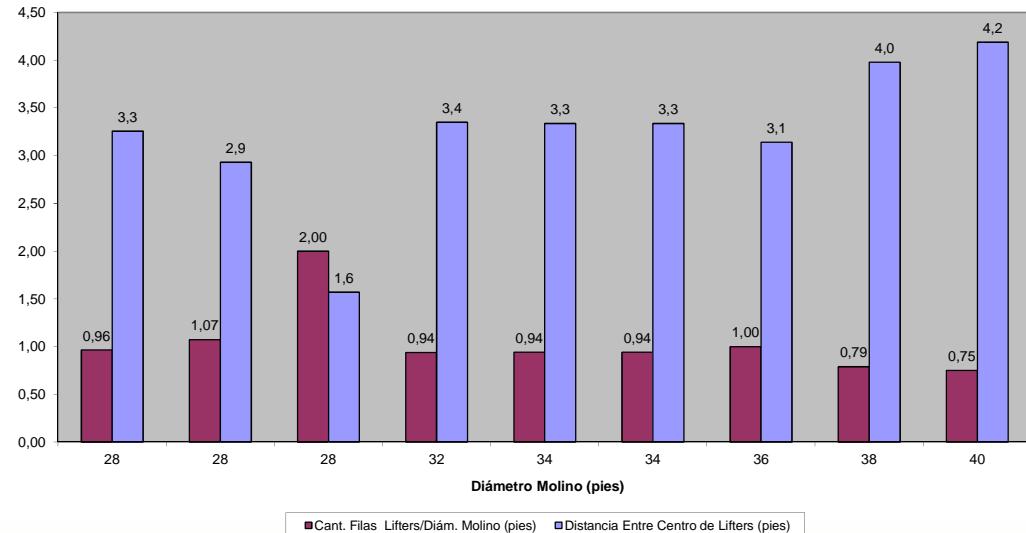
Lining



SAG Mills Linings Design: Relation Between SAG Diameter and Row Lifters Number

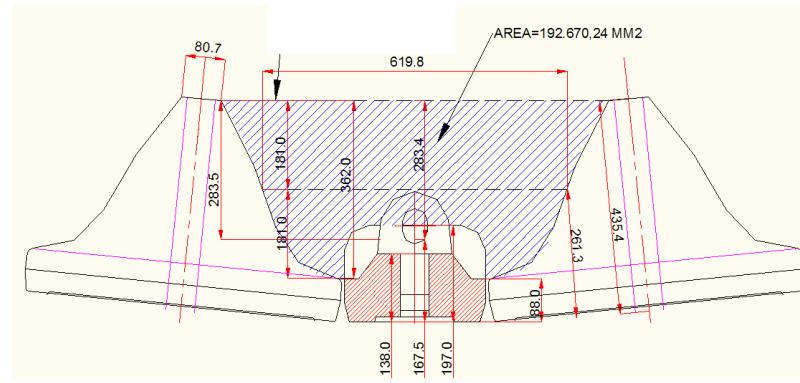
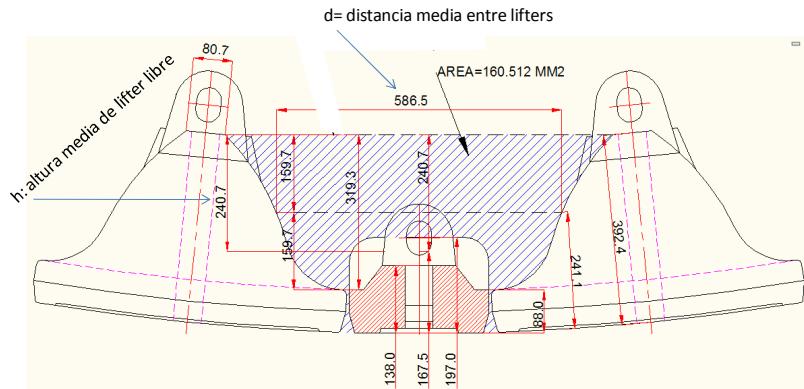


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SAG Mills Linings Design: SAG 1 - 2



	Original design	Proposed design	Average industry
d/h	2,44	2,19	2,32
V between lifters	6,9%	8,3%	7,7%
h/mill diameter	2,5%	2,9%	2,8%

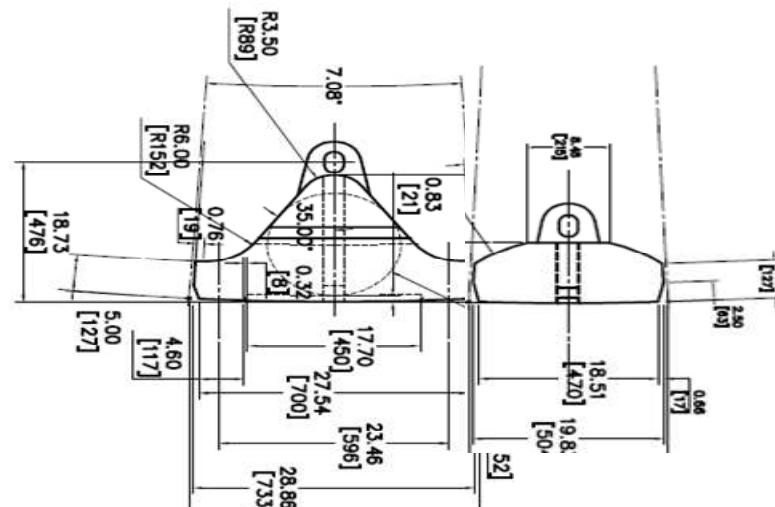
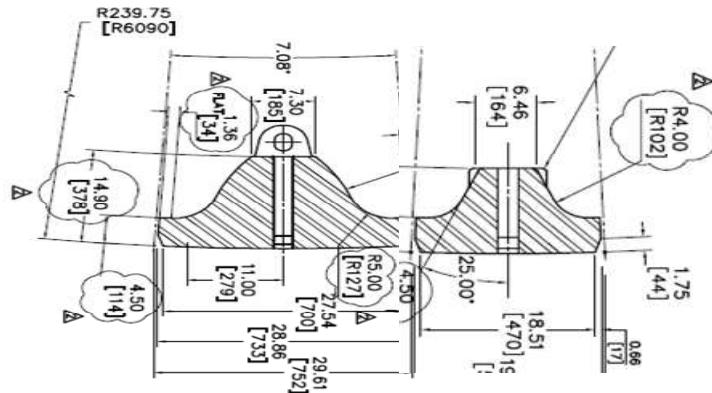
Differences:

- Smaller superior lifting angle (42° vs 52°)
 - Fall of the load near to foot of load
- Bigger lifting angle in intermediate area (26°)
 - Better energy distribution and bigger load in flight
 - Lifting capacity independent of the waste
- Bigger lifters height: 43 mm
 - Bigger load volume in flight
 - Bigger duration of the lining (15% with 150 mm of retirement thickness)

Lining



SAG Mills Linings Design: SAG 1011



	Original design	Proposed design	Average industry
d/h	4,37	3,19	2,32
V between lifters	5,1%	6,9%	7,7%
h/mill diameter	1,6%	2,4%	2,8%

Differences:

- Variable angle since 35°
 - Fall of the load near to foot of load
 - Better energy distribution and bigger load in flight
 - Lifting capacity independent of the waste
- Bigger lifters height: 71 mm
 - Bigger load volume in flight
 - Bigger duration of the lining (18% with 150 mm of retirement thickness)

Lining



Trommel's Classification Efficiency

SAG Plant	Mill Diameter, feet	Trommel's Dimension		Screen	Capacity tph	Slot Size		Open Area, %
		Diameter, feet	Long, feet			Wide, mm	Long, mm	
C.M.D.I. Collahuasi	32	14,4	13,6	No	1.320	15	30	27,0
Minera Los Pelambres	36	15,9	16,4	No	2.912	17	38	26,0
Minera Escondida	38	20,3	11,2	Si	5.170	25	60	29,0
Minera Antamina	38	15,9	16,4	No	5.472	15	38	23,0
C.M.D.I. Collahuasi	40	16,5	16,9	No	4.480	25	50	22,8
Minera Esperanza	40	15,4	15,4	Si	5.160	13	39	25,0

Comparison criteria: α parameter:

$$\alpha \left[\frac{m^3}{m^2 h} \right] = \frac{\text{Volumetric slurry flow} \left[\frac{m^3}{h} \right]}{\text{Open area} \left[m^2 \right]}$$

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Trommel's Classification Efficiency

SAG Plant	Mill Diameter, feet	Trommel's Dimension		Pulp Flow, m³/h	Trommel Area, m²	Free Area, m²	Flow by Free Area, m³/m²/h
		Diameter, feet	Long, feet				
C.M.D.I. Collahuasi	32	14,4	13,6	935	57,0	15,4	61
Minera Los Pelambres	36	15,9	16,4	2.063	75,9	19,7	105
Minera Escondida	38	20,3	11,2	3.570	66,2	19,2	186
Minera Antamina	38	15,9	16,4	3.877	76,0	17,5	222
C.M.D.I. Collahuasi	40	16,5	16,9	3.174	81,2	18,5	172
Minera Esperanza	40	15,4	15,4	3.656	69,4	17,3	211

- 32 feet Collahuasi SAG mills, have the best condition of slurry evacuation in trommel: $\alpha = 61 \text{ m}^3/\text{h}/\text{m}^2$
- Antamina's SAG mill has the worst condition of slurry evacuation in trommel: $\alpha = 222 \text{ m}^3/\text{h}/\text{m}^2$
- Esperanza and Escondida's SAG mills have high values of α , but they have a screen
- Trommel of 40 feet SAG mill of Collahuasi has an high value of $\alpha = 172 \text{ m}^3/\text{h}/\text{m}^2$.

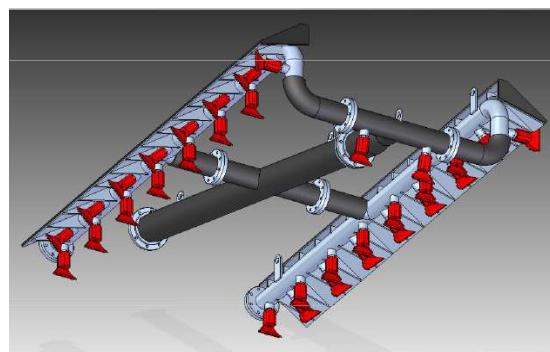
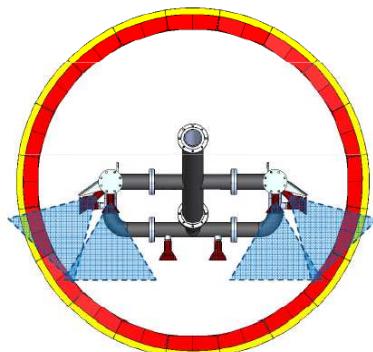
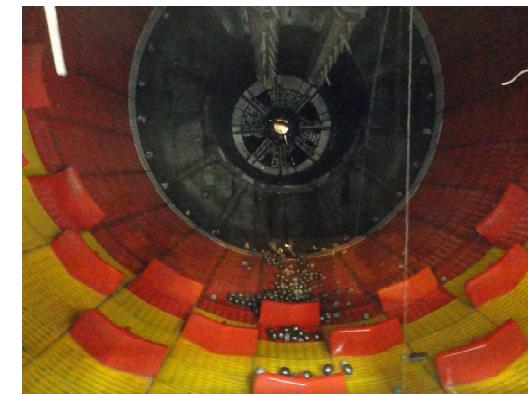
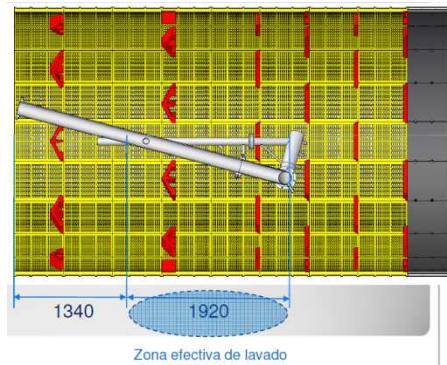
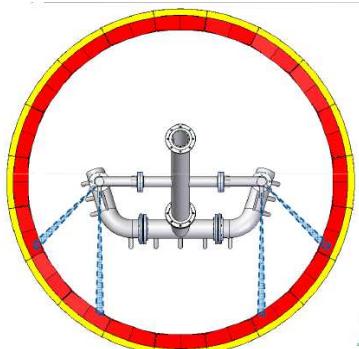
SAG 1011	Open Area, %	Pulp Flow, m³/h	Free Area, m²	Flow by Free Area, m³/m²/h
Initial Condition	22,8	3.174	18,5	172
Modification 1	35,0	3.174	28,4	112
Modification 2	31,8	3.174	25,8	123
Modification 3	29,2	3.174	23,7	134

- 28% more than the free area permit 22% more than flow discharge capacity

Ling



Trommel's Classification Efficiency: Laundry Water



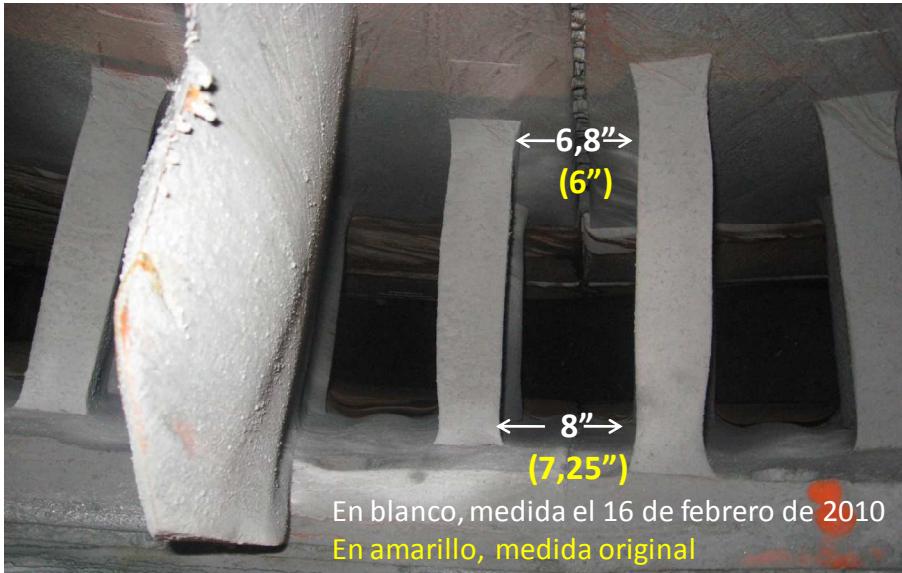
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SAG 1 - 2

SAG 1011



Pulp Lifters and Cone Discharge of SAG Mills



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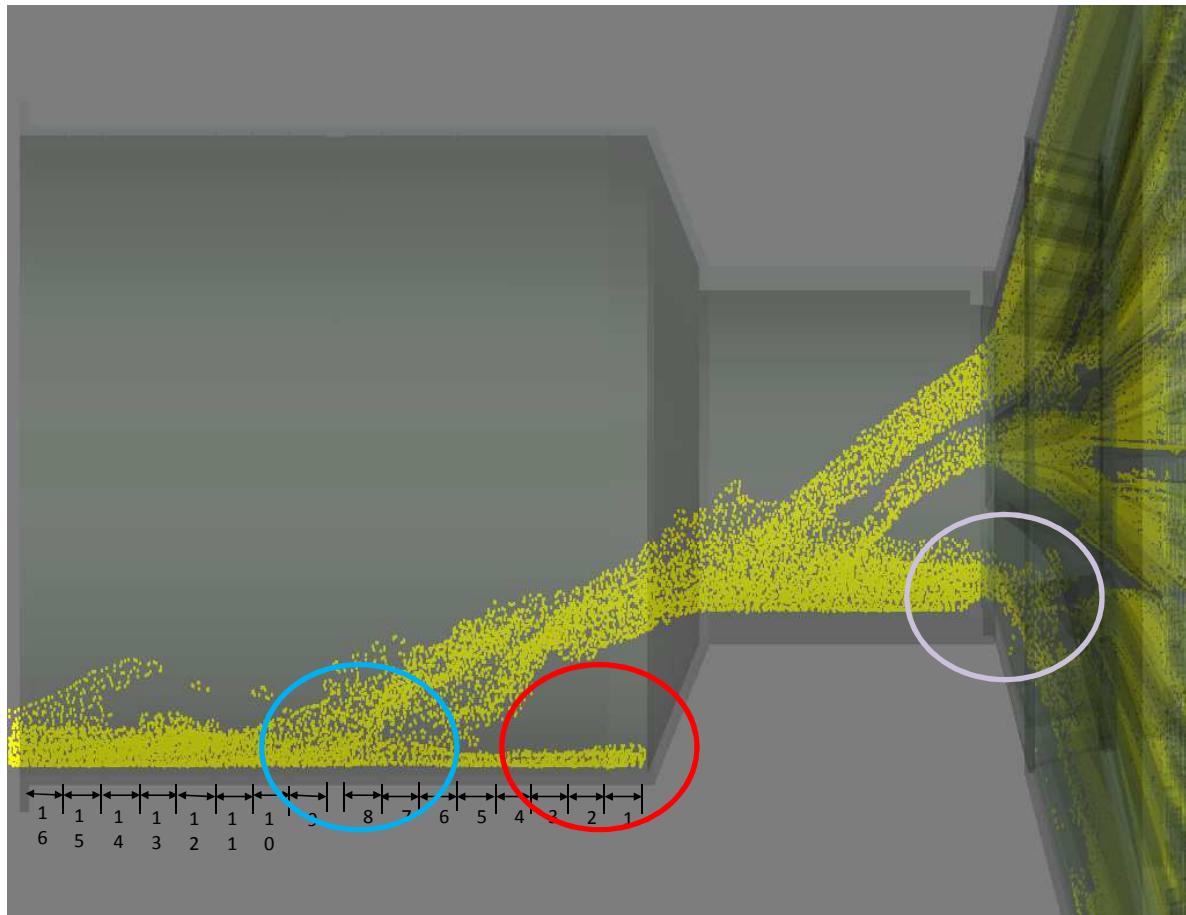
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Pulp Lifters and Cone Discharge of SAG Mills



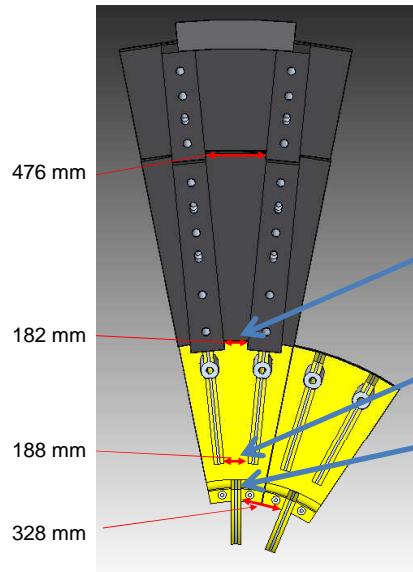
Cone discharge design affect:

- Discharge flow capacity (then, mill capacity)
- Slurry trajectory
- Slurry return from the trunnion
- Use of the trommel area for classification
- Excessive wear in preferential areas of the trommel

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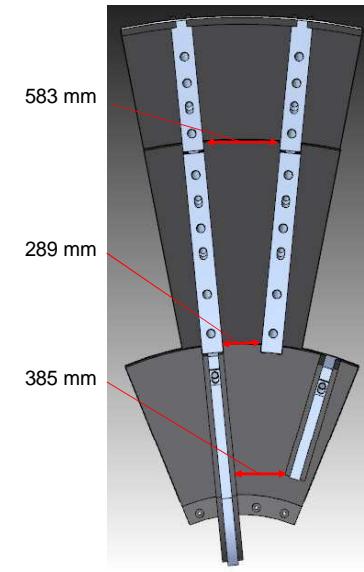


Pulp Lifters and Cone Discharge of SAG Mills



- Size of SAG Grade: 64 mm
- Strangulation of 182 mm
- Strangulation of 188 mm
- Opposing directors

Material: Polyurethane



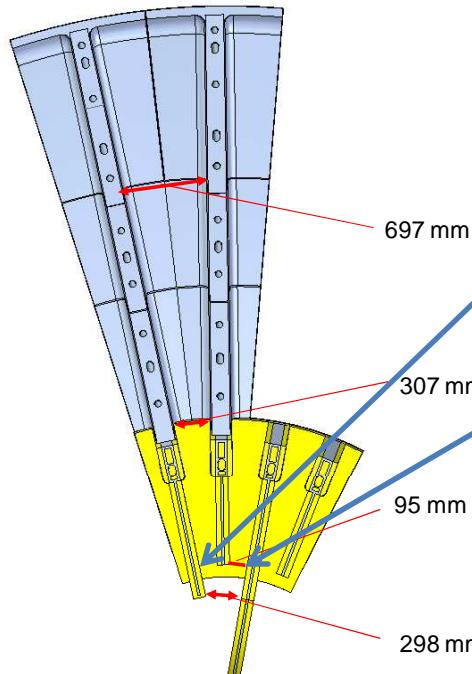
Material: Rubber
with ceramics

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Cone discharge of SAG 1 - 2

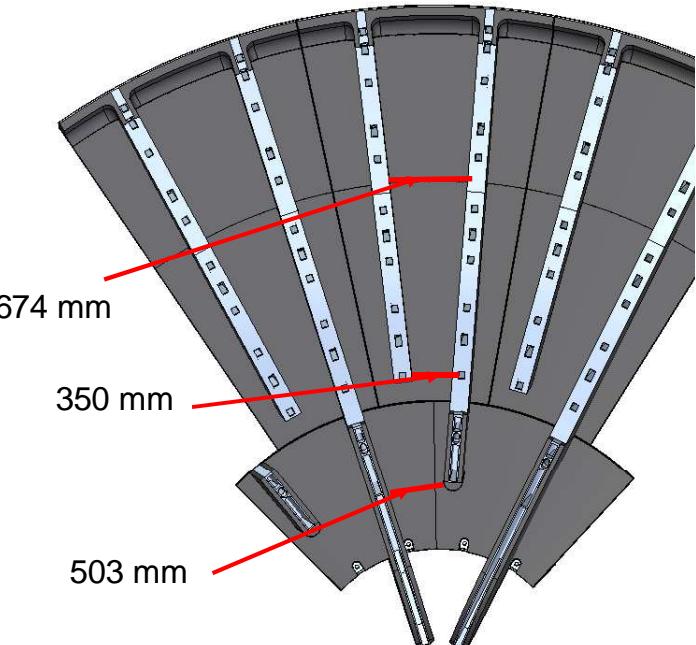


Pulp Lifters and Cone Discharge of SAG Mills



- Size of SAG Grade: 64 mm
- The short directors is near to medium directors
- Strangulation of 95 mm

Material: Polyurethane



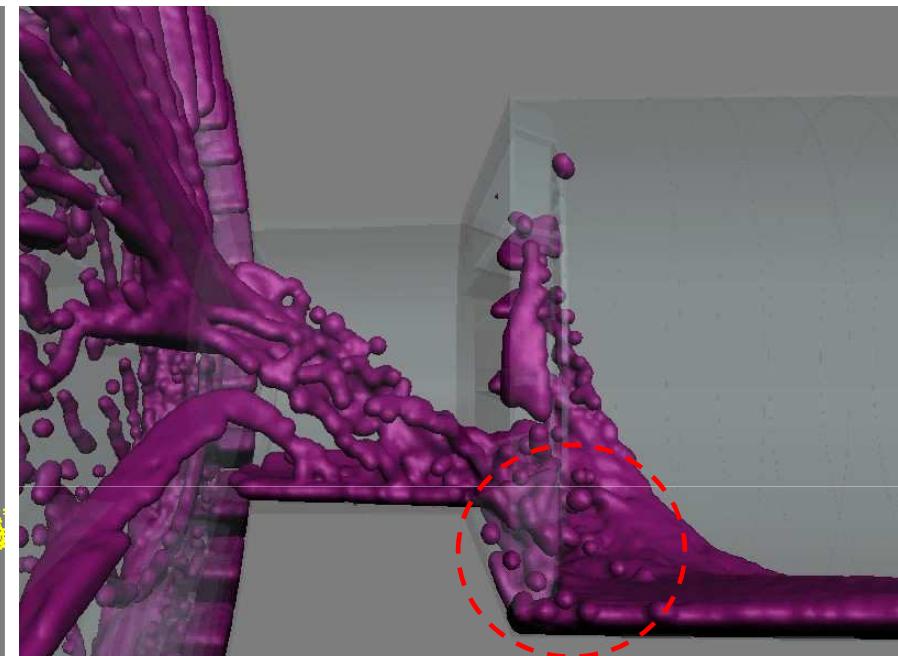
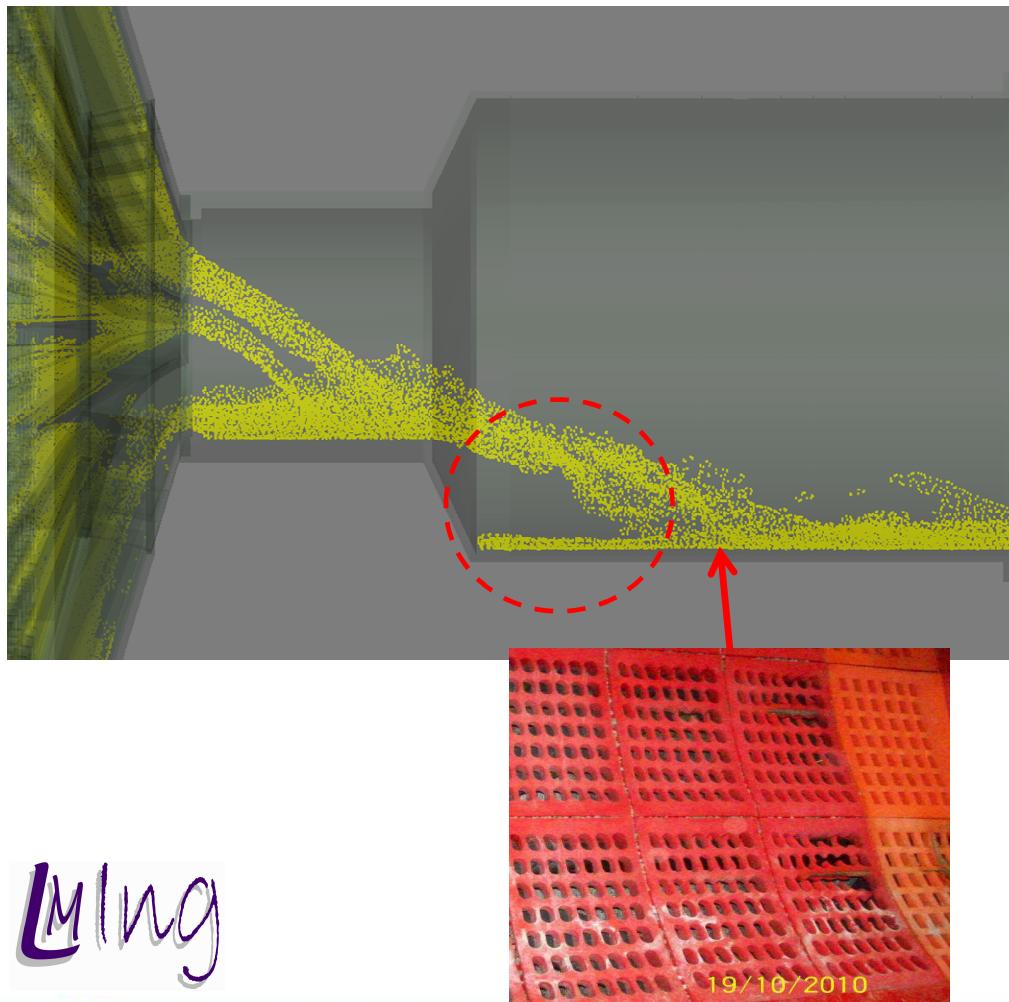
Material: Rubber
with ceramics



Cone discharge of SAG 1011



Charge Baffle in SAG 1011 Trunnion - Trommel



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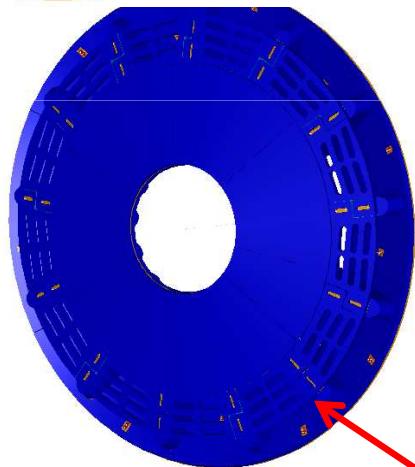
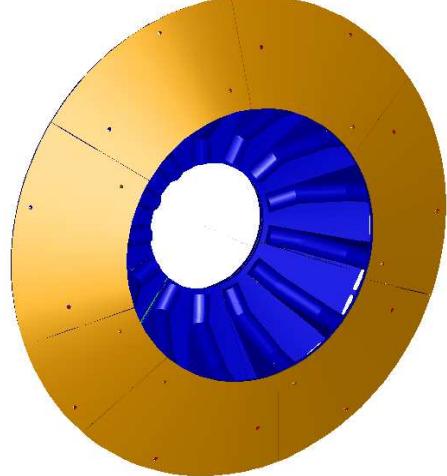
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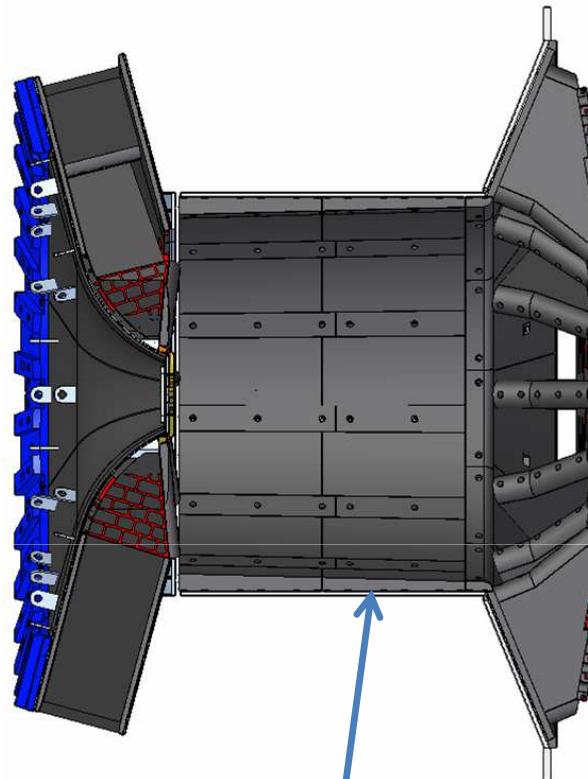
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Charge Baffle in SAG 1011 Trunnion - Trommel

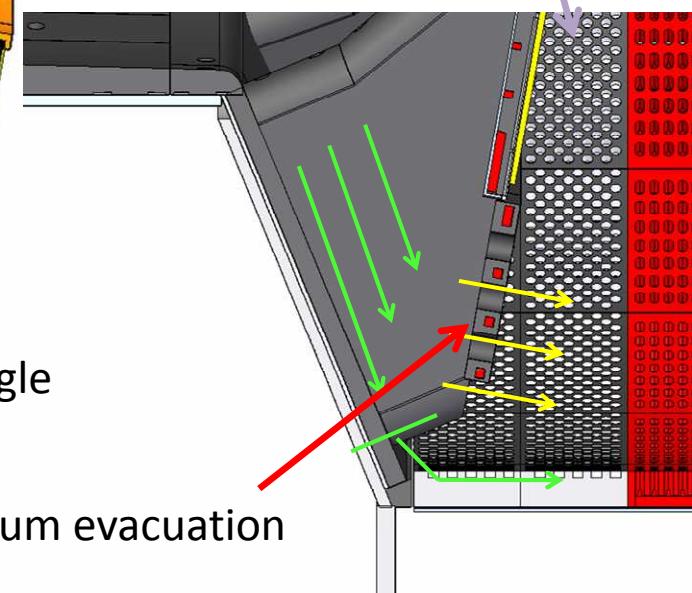


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Trunnion liner with positive angle

Grates in discharge zone, for maximum evacuation



It is possible to
eliminate one
blind line



Plant Results

SAG 1 - 2:

- The cylinder liners useful life increased in 15% (from 4,6 Mt to 6,3 Mt)
- Ball load level increased since 12 to 16%, and until 18%, without risk of damage of linings
- Bigger operational speed from the beginning of useful life of liners
- By pass of fines decrease (washed pebbles)
- Mill capacity increased up to 1.800 tph (from 1.400 tph, 28%)

SAG 1011:

- The cylinder liners useful life increased in 34% (from 8,5 Mt to 11,4 Mt)
- Ball load level increased since 14 to 16%, without risk of damage of linings
- Bigger operational speed from the beginning of useful life of liners
- The trommel's mesh useful life increased from 45 to 75 days
- Strong decrease of by pass of fines (washed pebbles)
- Pebbles belt is not a restriction of the process and the accidental detentions (for massive discharge of load) were eliminated
- Mill capacity increased up to 5.500 tph (from 3.900 tph, 41%)

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Plant Results

We want to thank to all the suppliers that have participated and contributed their experience and commitment in the carried out developments.

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