Procemin·GEOMET 2019

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6th International Seminar on Geometallurgy

SAG Mill Liner Selection to Maximise Productivity

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Context

- Key drivers of SAG mill performance
- Predicting liner wear
  - Ausgrind
- Design liners for throughput vs. Life
- Requirements of optimum liner design

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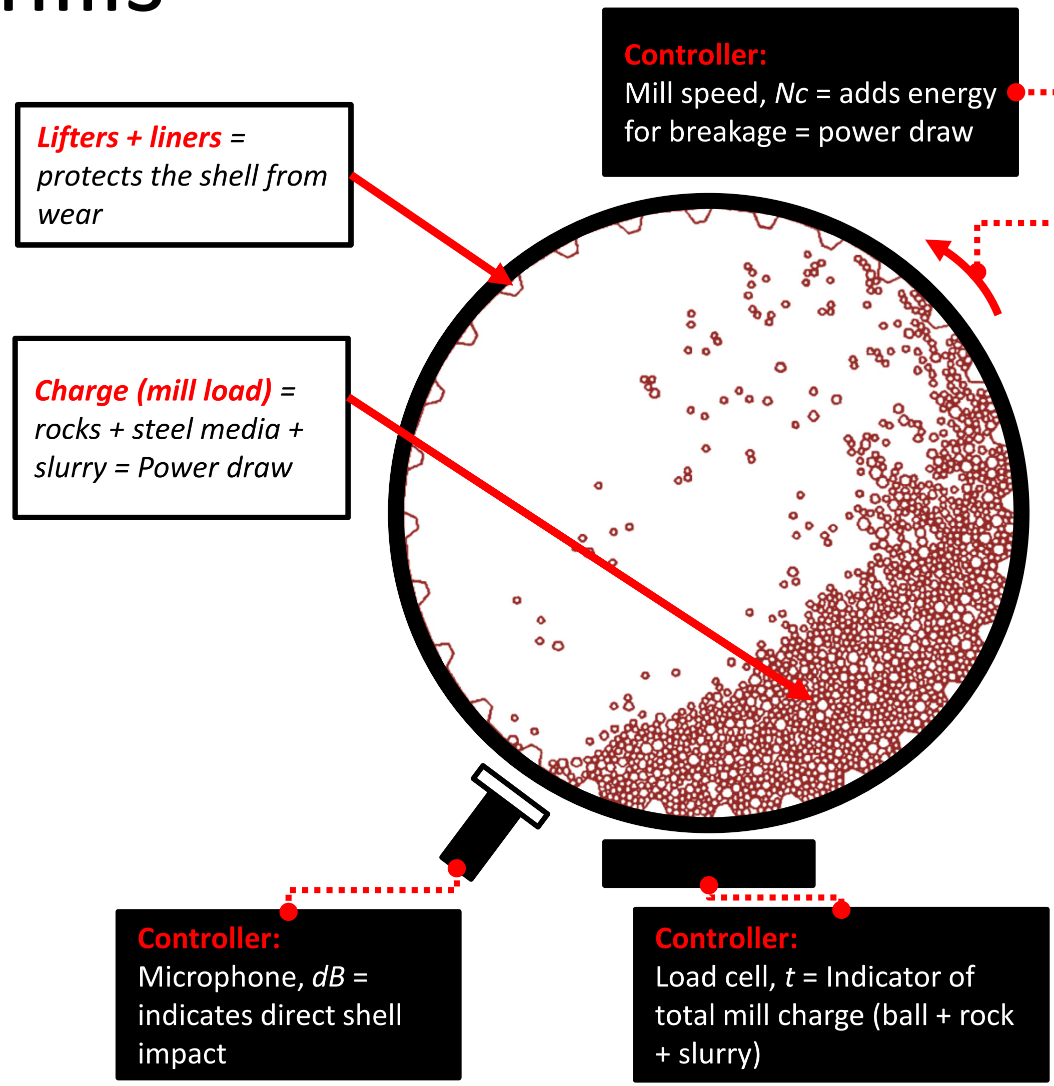
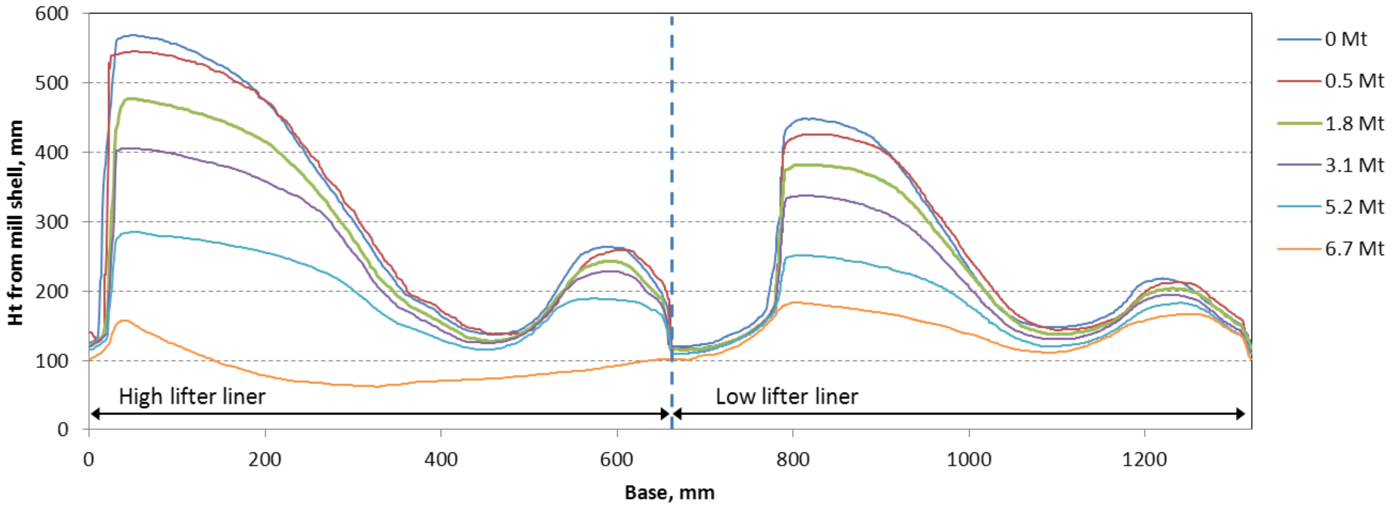
Optimising SAG mills

- Objective
  - Optimised load
  - Increased liner life
  - Increased throughput / flowrate
  - **Optimise power draw = increase throughput**
- Limitations
  - Structural load limit
  - Noise impact limit
    - Restricted by shell liner design



Liners – Model Development

- Cadia SAG mill data (Key drivers of wear life)
  - Ore composition
  - Volume / mass of steel
  - **Hypothesis – 'Liner shape defines the wear rate profile and the resulting life of liners'**



Bird et al – Applying mill control to account for liner wear on the Cadia 40ft mill, SAG 2015

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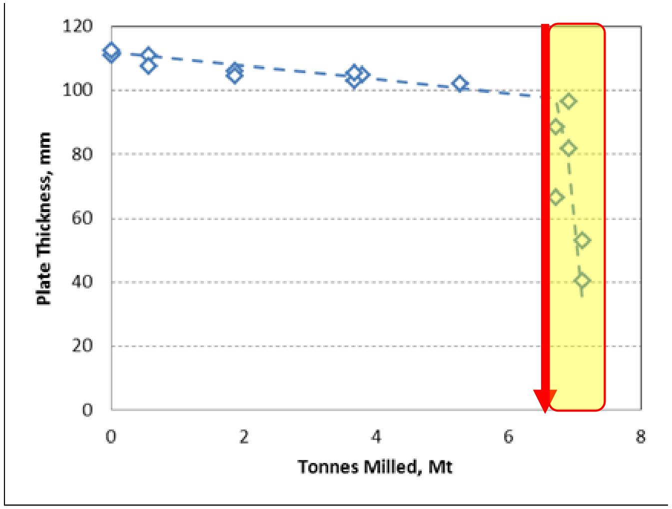
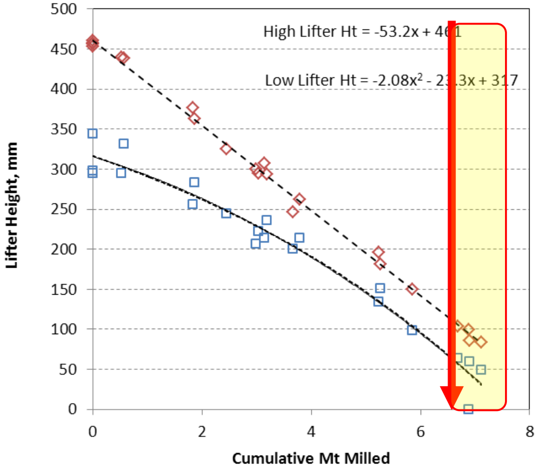
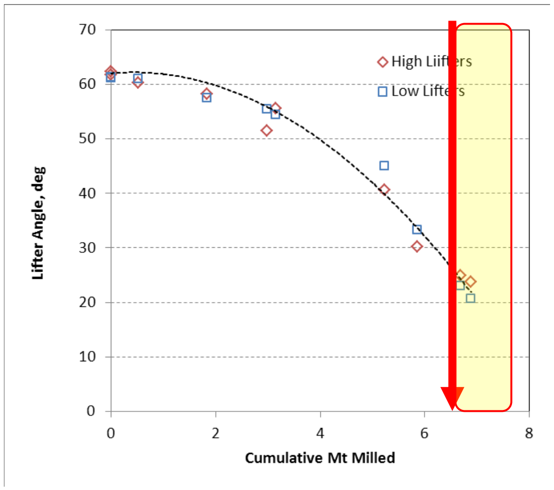
Liners – Importance of Face Angle





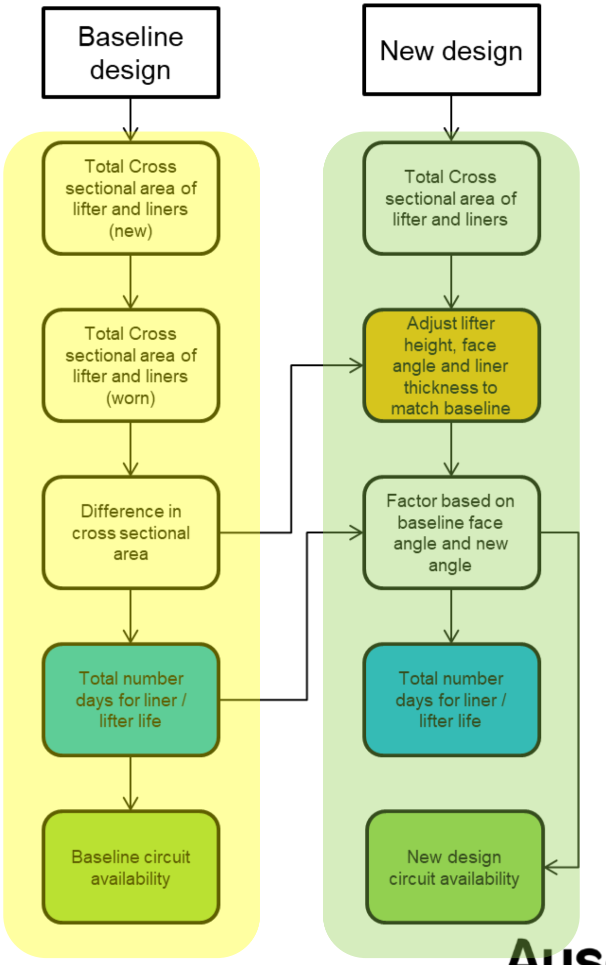


Bird et al – Applying mill control to account for liner wear on the Cadia 40ft mill, SAG 2015

- Face angle drives the liner wear rate
  - Once the lifter face angle reaches a critical angle, wear rates accelerate **(YELLOW REGION):** due to the change in the relative friction angle between the contacting surfaces

Predicting Liner Wear in Ausgrind

- Use known liner performance to predict future liner design
- Assumptions
  - Similar treated ore
  - Identical material type / composition as the basecase liner design
- Wear mainly affects the:
  - Face angle
  - Lifter height
  - Liner plate thickness



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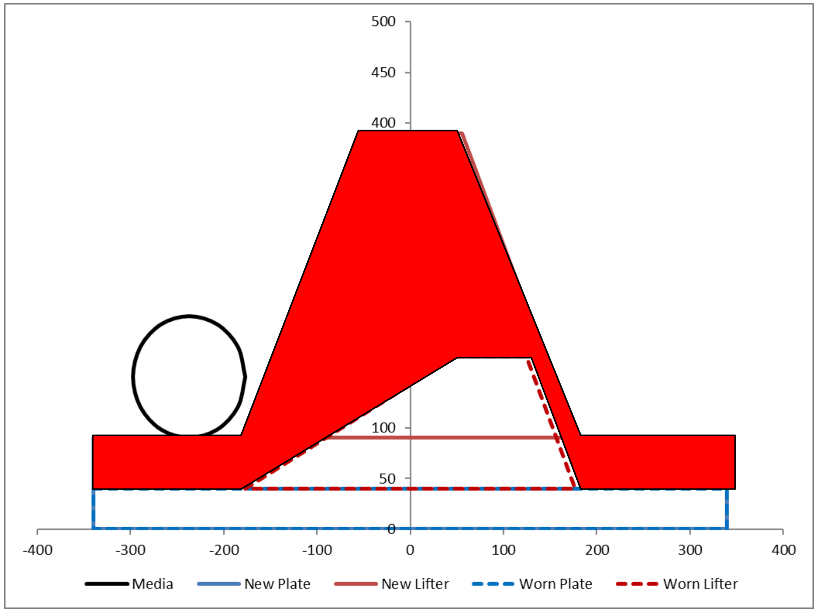
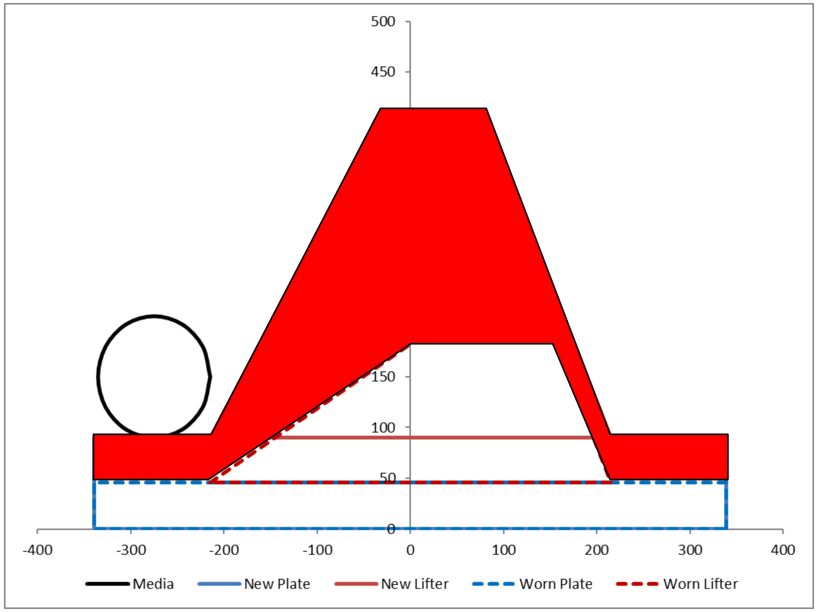
Liners – Ausenco Wear Model

Base case liner design



Test liner design



- Parametric model
  - Plate thickness and face angle are linked parametrically
  - New liner's thickness and face angle dimensions are adjusted to match the equivalent cross-sectional area / volume loss as the base case (RED AREA)
  - Extended life of the test liner is then calculated by determining time taken to reach critical face angle or plate thickness

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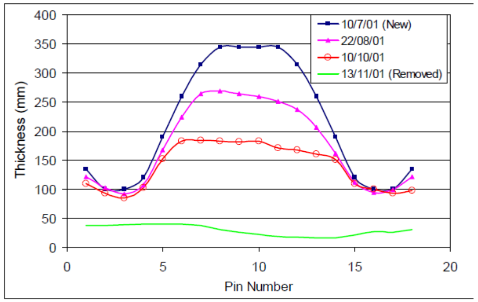
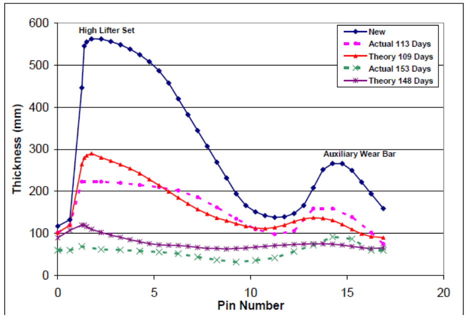
Liners – Cadia Example

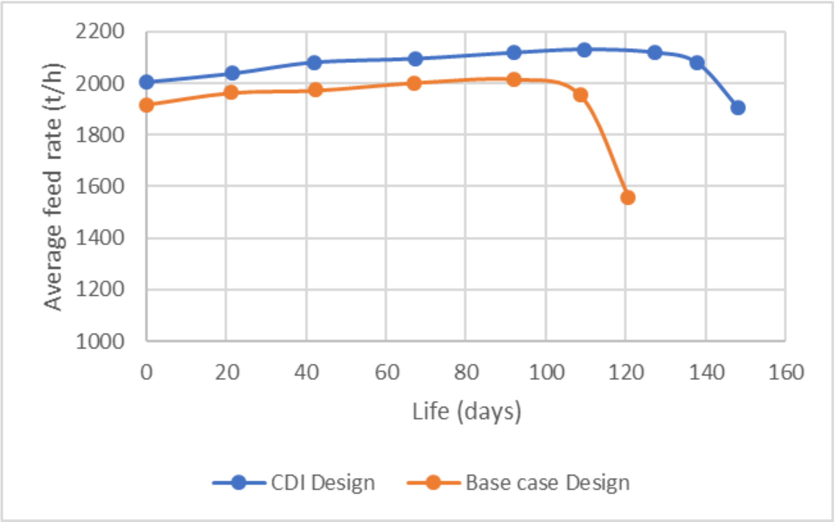
Shell Profile	Base case	CDI design
Face angle (deg)	30	28
Rear angle (deg)	40	5
Lifter height (mm)	250	422
Plate thickness (mm)	115	145
Total mass (t)	351	420
Life to max performance (days)	90	113
Predicted (Ausgrind)	-	119
Life at change out (days)	120	143
Predicted (Ausgrind)	-	149



Base case



CDI Design



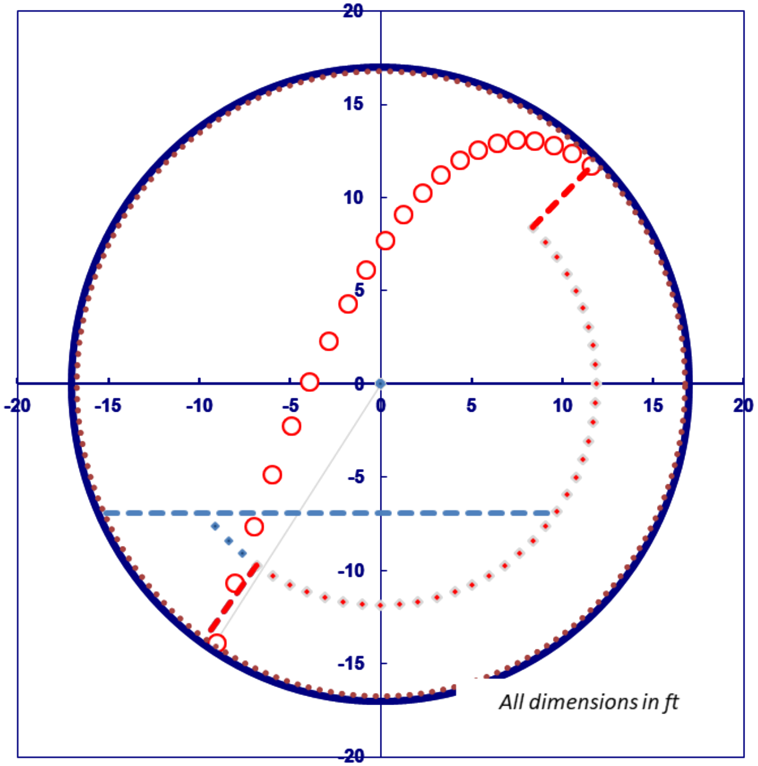
Hart et al – Development of Shell Liner Design at Cadia using DEM, SAG 2006

Liners – Phu Kham Example

Shell Profile	Base case	Design 1	Design 2	Design 3
Face angle (deg)	22	25	35	30
Rear angle (deg)	22	9	10	23
Lifter height (mm)	300	310	340	320
Plate thickness (mm)	90	120	130	90
Life at change out (days)	161	`	177	158
Predicted (Ausgrind)	-	183	173	155

Trialled liners (Mill Ops 2018)

Ausgrind – SAG Mill Optimisation



No Pooling = 12.3 MW (14% grate OA)

Pooling = 11.6 MW (5% grate OA)

- Trajectory calculation
  - Molycop tools' spreadsheet calculation (based on Powell trajectory model 1991)
- Power Model calculation (Charge profile)
  - Morrell power draw 2016 (presented at Comminution 2014)
- Slurry Pool calculation (discharge capacity)
  - Latchireddi slurry pool model 2002

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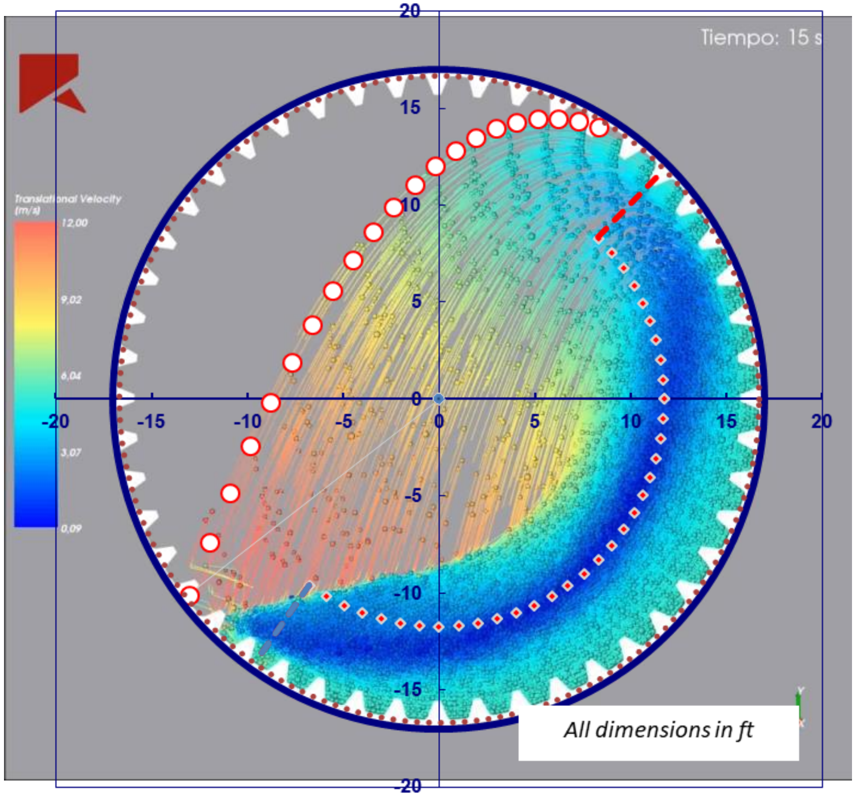
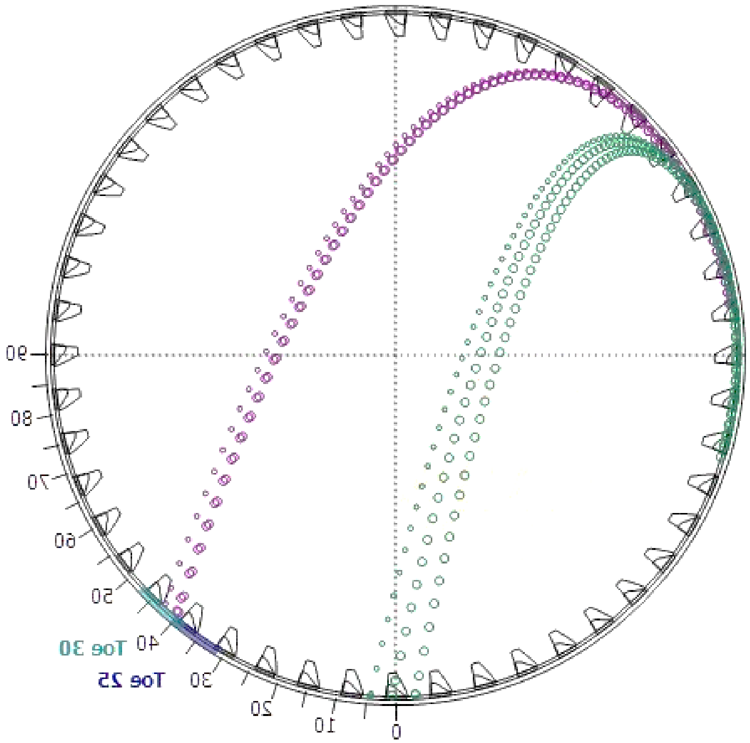
Ausgrind - Validation



DEM Validation



MillTraj Validation

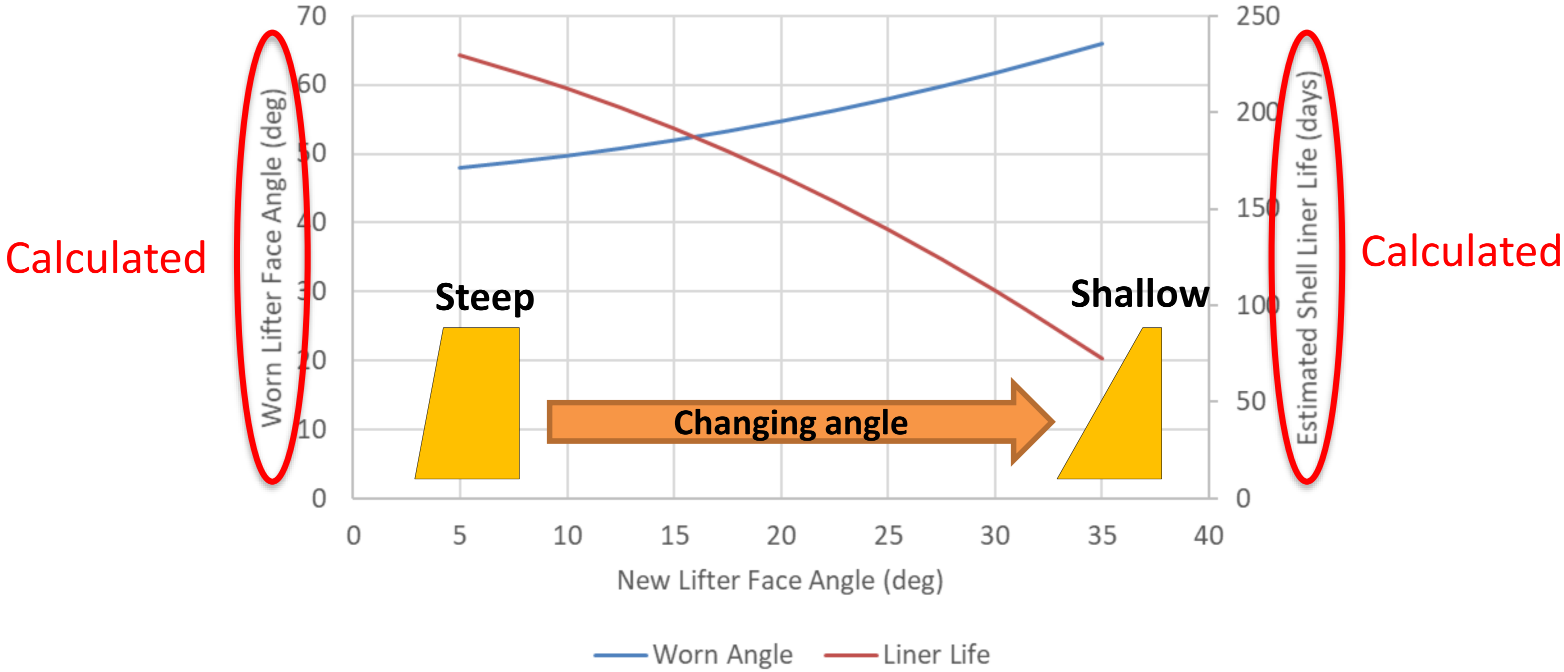
Liners for Life vs. Throughput

- Phu Kham SAG Mill liner performance as basis of analysis
- Analysis assumptions
  - Same tonnes processed
  - Similar rate of mass loss
  - Uni-directional operation
  - Similar type of ore processed
  - Based on baseline 96 % availability

Shell Profile	New Shell Profile	Worn Shell Profile
Plate thickness, mm	90	40
Lifter height, mm	390	170
Lifter face angle, degrees	22	60
Lifter rear angle, degrees	22	22
Total operational life, days	-	161

Designing Liners for Life

- Changing lifter face angle (fixed height)



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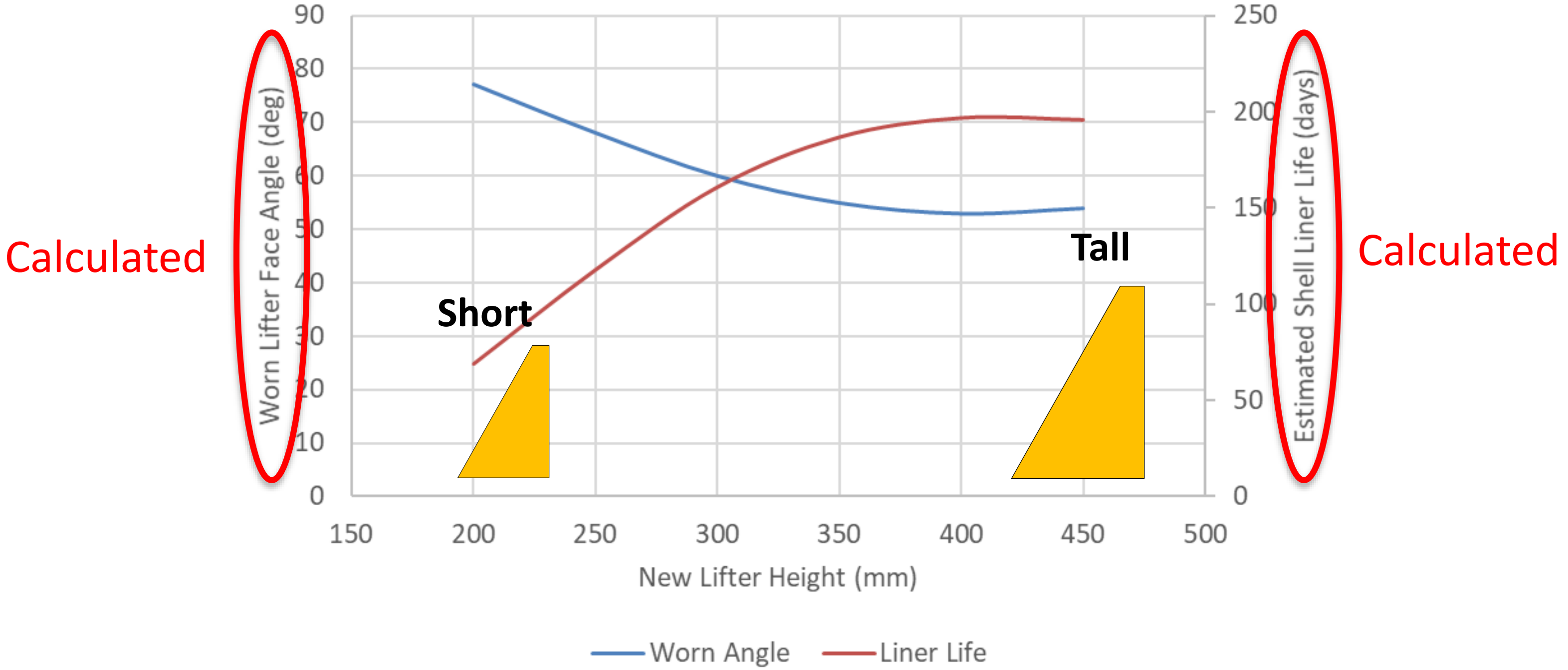
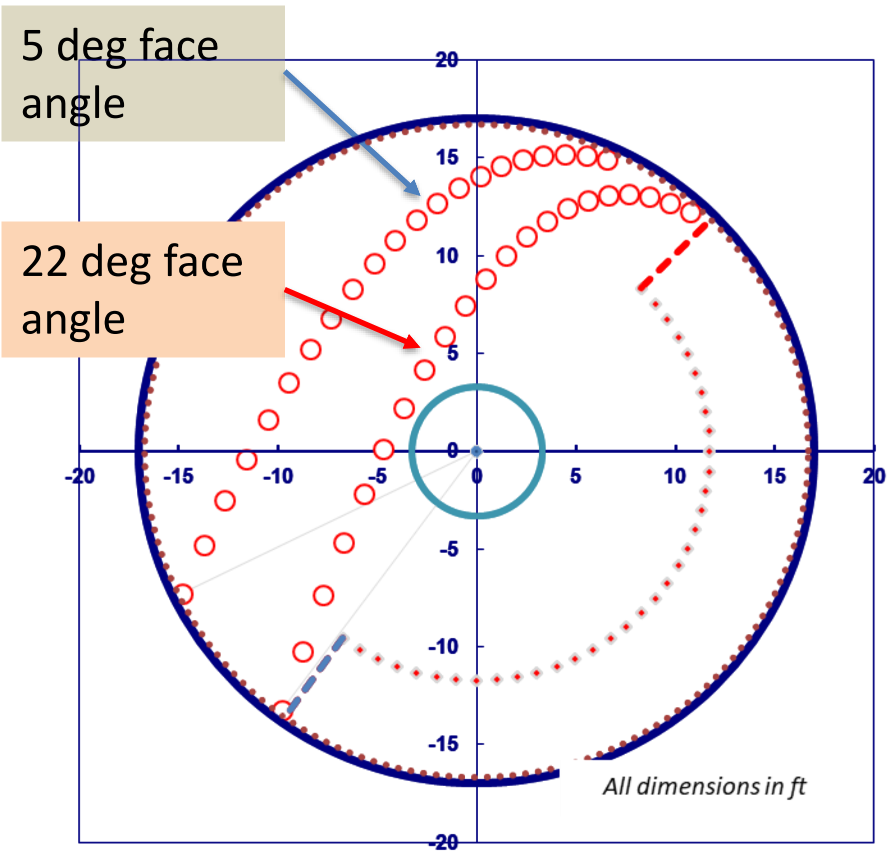
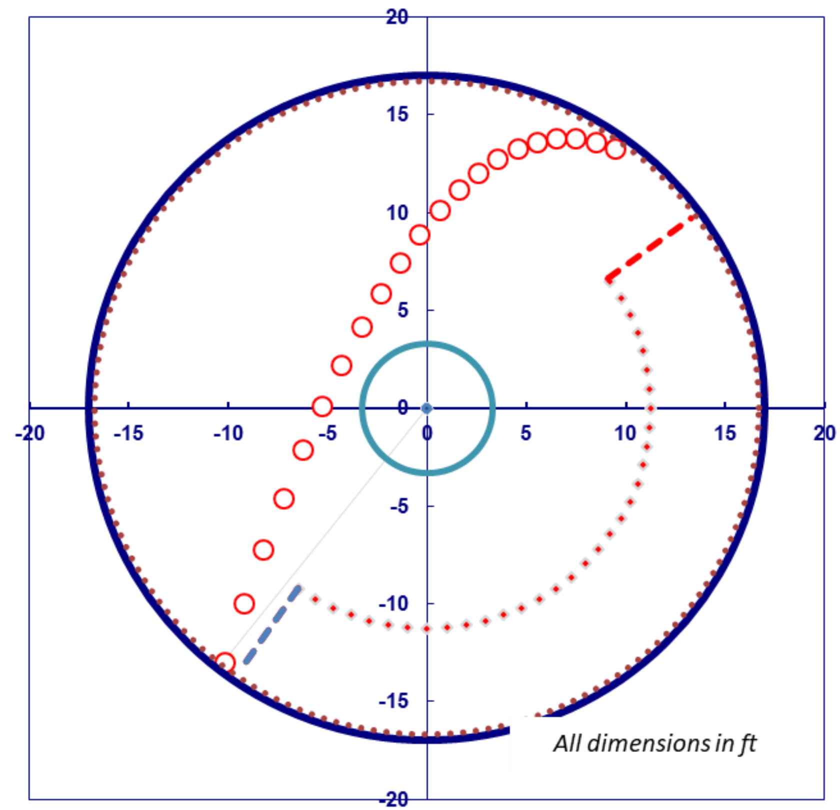
Designing Liners for Life

- Changing lifter height (fixed face angle)



Power Draw – F_n of Face Angle

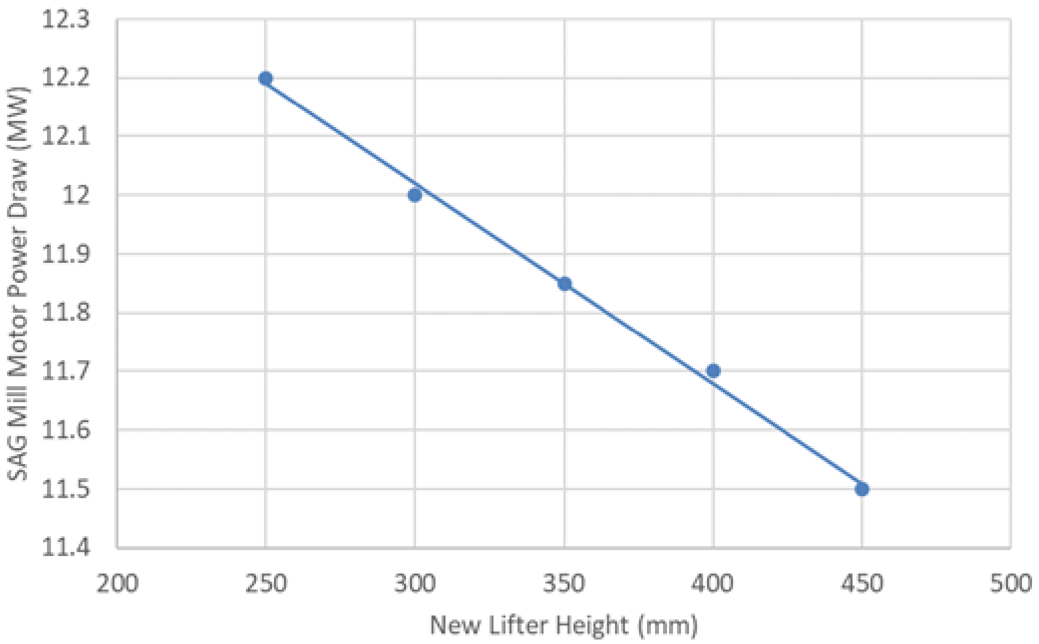




- Speed = 75% Nc
- Ball load = 15%v/v
- Total Filling = 28% v/v
- Power Draw = 11.9 MW

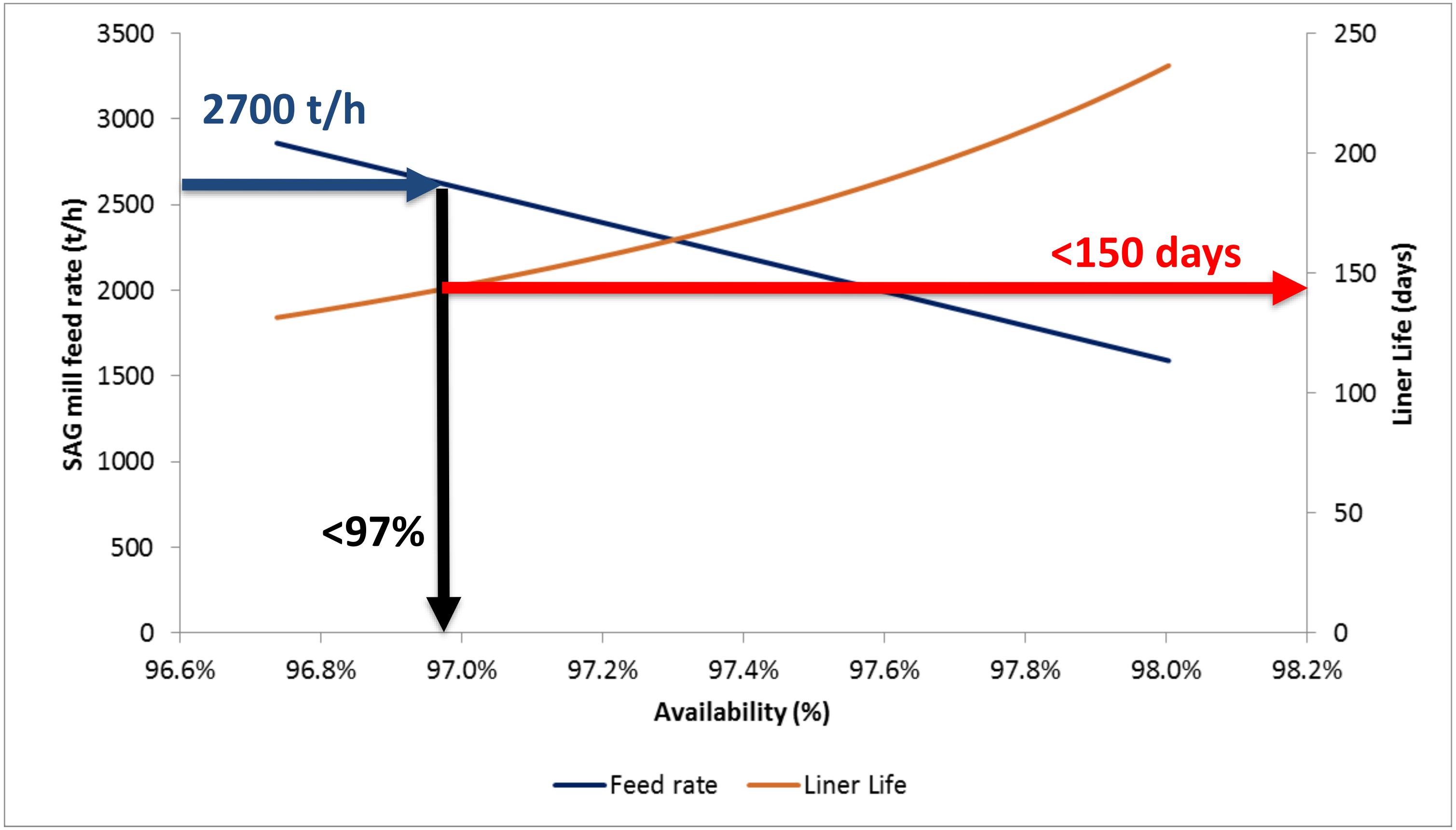
- **Speed = 65% Nc**
- Ball load = 15%v/v
- Total Filling = 28% v/v
- **Power Draw = 10.0 MW**

Power Draw – F_n of Lifter Height

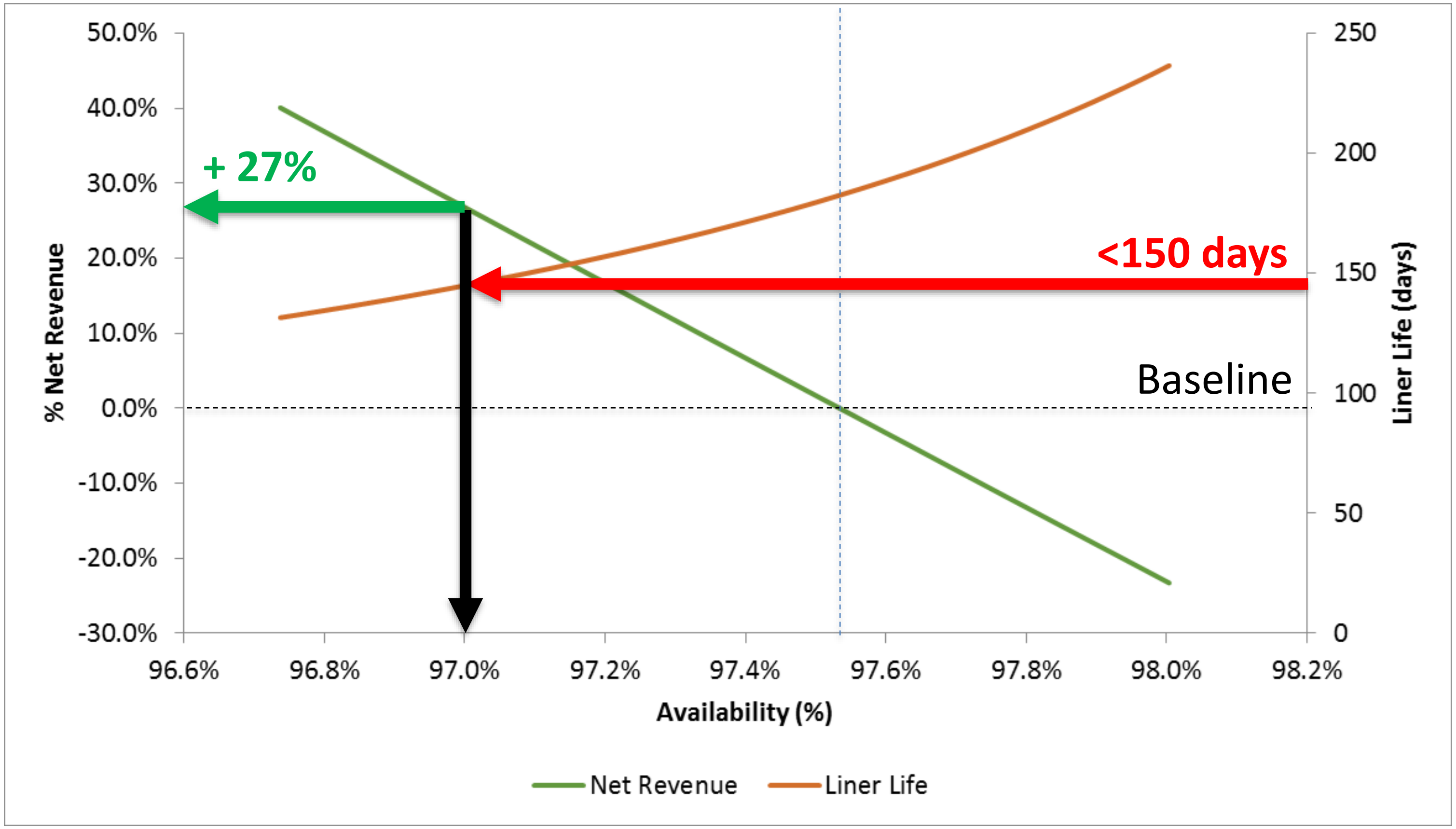


- Lower lifter height = increased mill volume = higher power draw

Which is Better?



Which is Better?



Takeaway Points

- Designing liners for life
  - Reduced operable speed range
  - Reduced power draw at optimised load
  - Sacrifices throughput
- Designing liners for throughput
  - Maximises operable speed range
  - Maximises power draw at optimised load
  - Sacrifices life (overall availability)

Selecting Optimum Liner Design

- For friable ore = High throughput (lower SAG mill load)
  - **Design objective = maintain optimum SAG mill load**
  - Requires lower operable speed range to maintain load
  - Select liners for life (i.e. high face angle, high lifters)
  - Longer liner life
- For competent ore = low throughput (high SAG mill load)
  - **Design objective = achieve higher operable speed range**
  - Requires higher operable speed range to maintain load
  - Select liners for throughout (i.e. low face angle, low lifters)
  - Shorter liner life

Thank you.