Choosing the Right Motors for your Mills

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Overview of Mill Selection

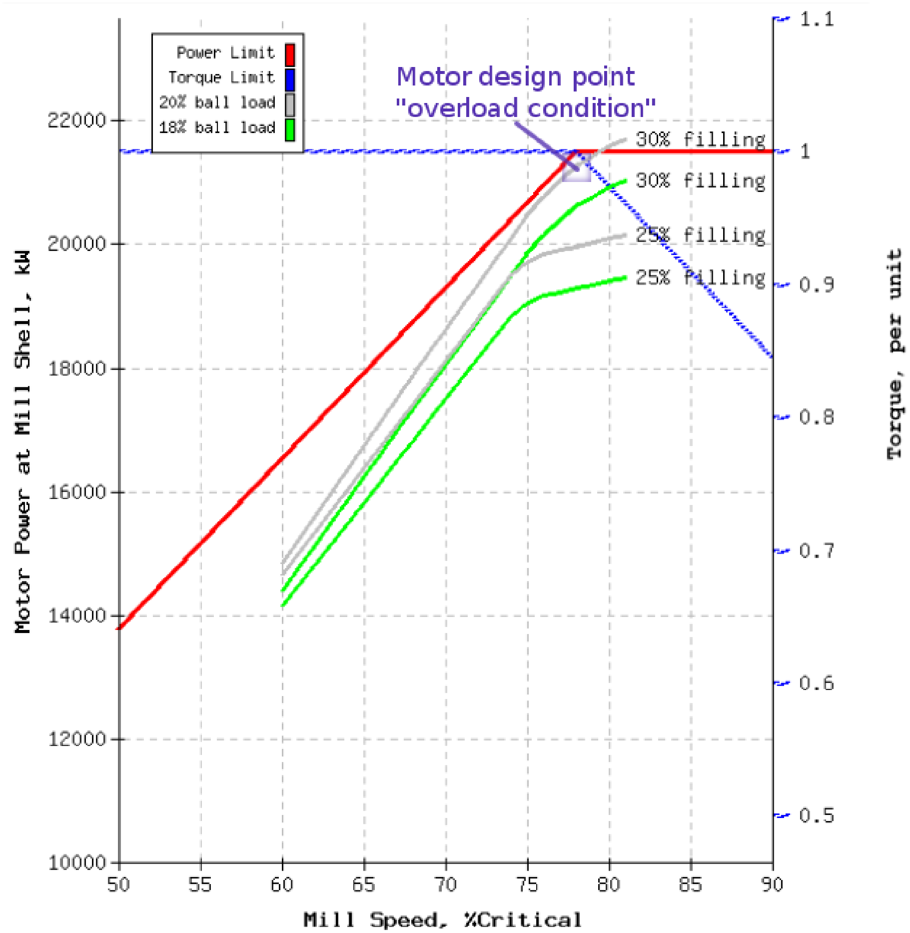
- Grinding testwork to characterise the project's oretypes
- Characterise hardness variability or load grinding results into block model
- Select mill sizes to achieve a desired throughput (or select a throughput based on desired mill sizes)
- Select motor(s) to fit the mills

Step 1: Mill overload power

- Determine a set of operating conditions that reflects the maximum “overloaded” condition that the mill should be able to handle:
  - SAG mills: 20% v/v ball charge, 30% v/v filling and 78% critical speed with worn liners
  - Ball mills: 36% v/v filling and 78% critical speed with worn liners

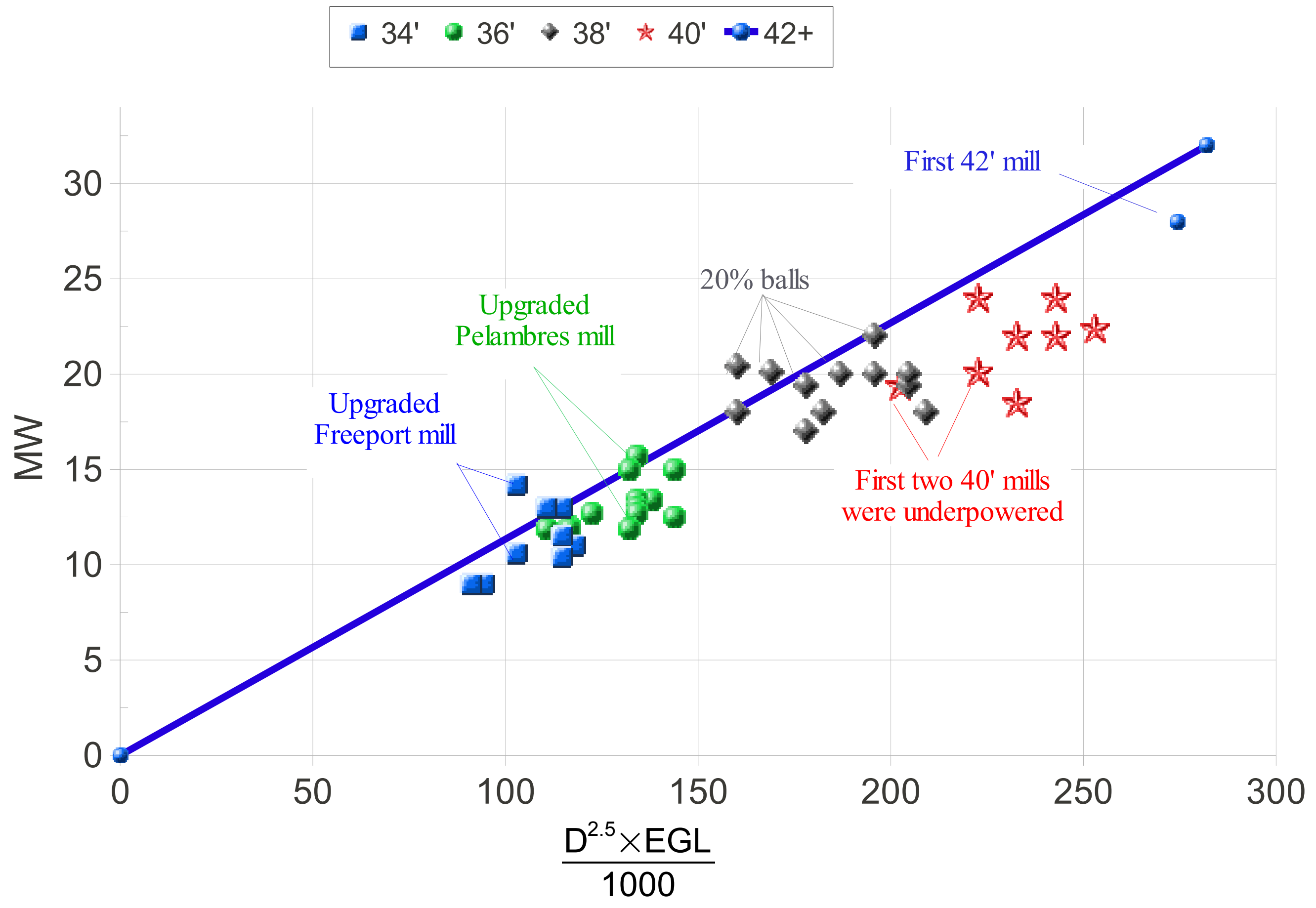
Step 1: Mill overload power

- SAG mill, use a Tent Diagram to identify the design requirements
- Example, SG=4.0 38'Ø × 19' EGL SAG
- Requires 21.5 MW at mill shell



Benchmarking Power

Large Mill Power



Step 2: Power measured where?

- The process conditions reflect power delivered to the mill shell
- The motor power reflects the motor output
- Motors with pinions and reducers must allow mechanical losses
  - makes the motor bigger to produce the same shell power

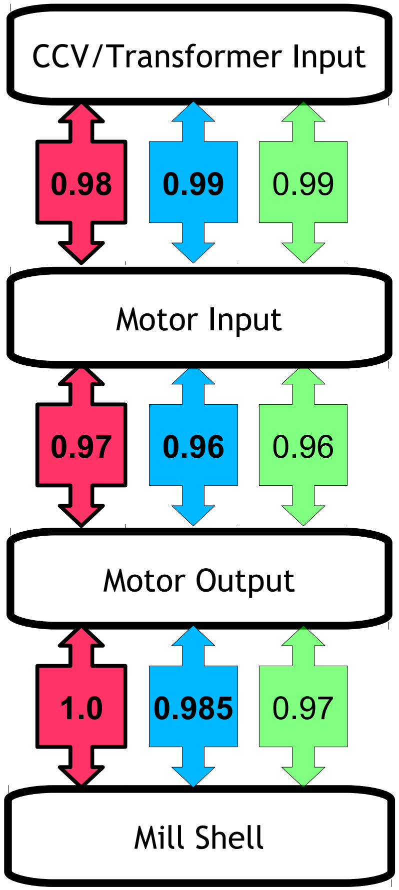
Step 3: Which Type?

- Three commonly used mill motor types:
  - Gearless drives
    - largest size, up to 28 MW
    - highest efficiency
  - Synchronous with pinion
    - one or two pinion configuration, up to 15.6 MW
  - Induction motor with speed reducer
    - one or two pinion configuration
    - cheapest capital, but poorest electric efficiency

Step 3: Which Type?

- Electrical efficiency
  - Gearless is highest
  - Induction is lowest
- Directly affects operating costs
  - inefficient motors consume more power

Gearless
Synchronous
Induction



Step 3: Which Type?

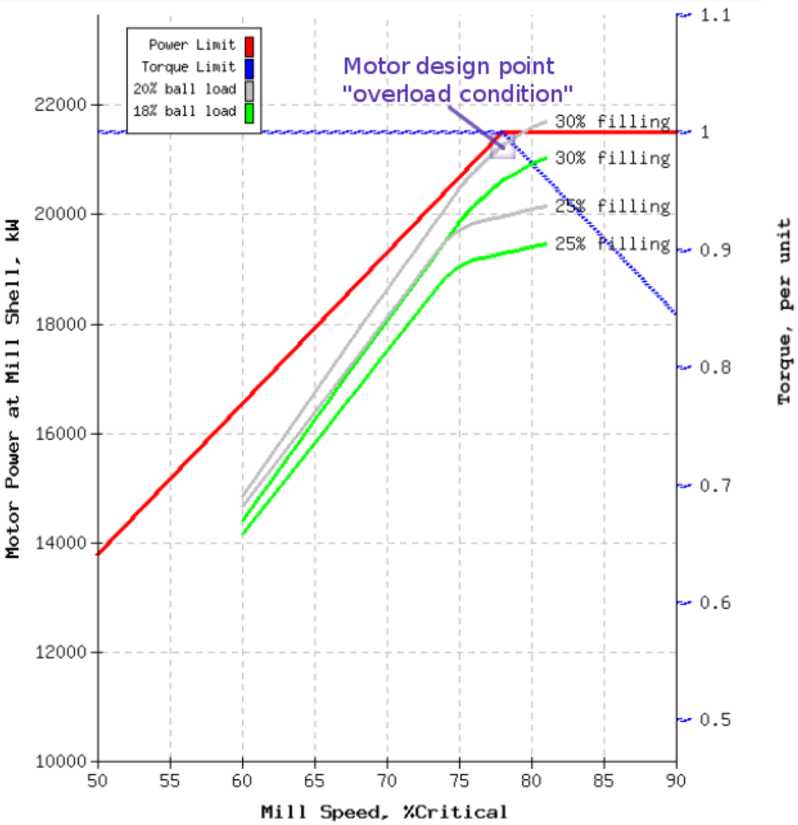
- Gearless is always variable-speed
- Synchronous and induction are normally fixed-speed
  - Can be made variable speed by adding more equipment and sacrificing electrical efficiency
  - In almost all cases, variable speed is cost-effective for SAG mills
  - Variable speed for ball mills depends on the particular project and ore

Step 4: Select Speed

- The rated speed of a motor is nominated by the engineer
- The torque output of a motor is constant up to the rated speed
- The power output of a motor is constant above the rates speed

Step 4: Select Speed

- Want the widest possible range of operating conditions



Case Study

- South American iron-ore project
- Variability in ore density
- 60,000 tonnes/day on 75% of samples
- Single line
  - 1 SAG, 38' Ø × 19' EGL
  - 2 ball mills, 22' Ø × 38' EGL

Case Study: Nominal operation

Case 03: one 38'x19' EGL SAG and two twin-pinion 22'x38' ball mills

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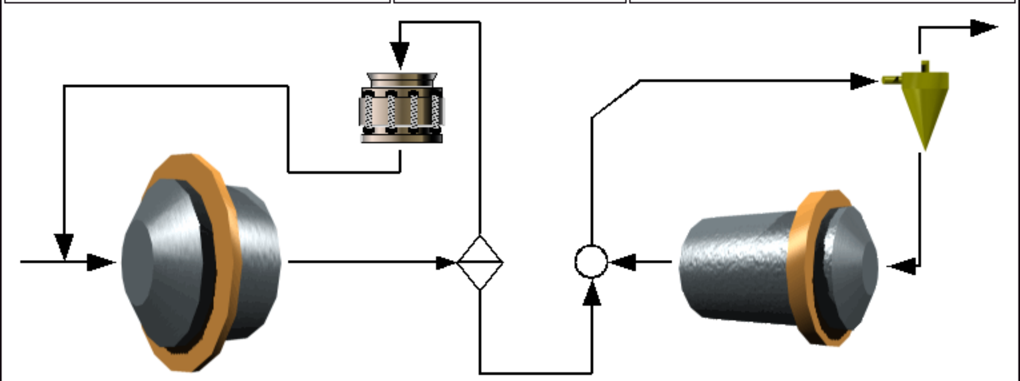
DJB0092 Circuit 3

Circuit Feed F_{80} = 150.0 mm Density = 3.08 t/m^3	Transfer T_{80} = 1,495 µm	Product P_{80} = 150.0 µm
Wi_C: 9.48 kW·h/t	Wi_{RM}: 14.30 kW·h/t	Wi_{BM}: 13.96 kW·h/t **



Primary Mill(s)	Pebble Crushers	Secondary Mill(s)
Usable shell power: 17,722 kW 1. Dimensions = 38´Ø x 19´ EGL E_{asag} = 6.37 kW·h/t	1. MP1000: 559 kW E_{peb} = 0.20 kW·h/t	Usable shell power: 18,354 kW 1. Dimensions = 22´Ø x 38´ EGL 2. Dimensions = 22´Ø x 38´ EGL E_{bm} = 6.60 kW·h/t

E_{ssbm} = 11.98 kW·h/t; Circuit operating Wi_O=16.66 kW·h/t (119% of Wi_{BM})
Total circuit power = E_{ssbm}+ 10.0% = E_{asag} + E_{peb} + E_{bm} = 13.18 kW·h/t

Ball mill operating Wi_O= 11.8 kW·h/t = 85% of Wi_{BM}

Estimated circuit throughput: 2,780 t/h * 24 h/day * 92.0%= 61,391 t/d

x

SAG Mill 1

Motor Rated Power = 21,500 kW [28,832 HP]
Power available at shell = 21,500 kW [28,832 HP]
Drawn Power at Shell = 17,722 kW [23,766 HP]
Dimensions = 38´Ø x 19´ EGL [11.6 m Ø x 5.8 m]
Speed = 9.8 RPM = 78.0 % critical
Filling = 25.0 % v/v total, 18.0 % v/v balls

Liner effective thickness 6.00 inches (0.500 feet)
Effective dimensions = 37.00´Ø x 19.00´ EGL
Critical speed is at 12.6 RPM
Ore density 3.08 tonnes/m^3
Charge density 4.52 tonnes/m^3
Grinding ball density 7.51 tonnes/m^3
Power at the DCS = 18,461 kW [24,756 HP]
edit

See Tent Diagram

Using DJB power numbers
278 Name: sag38x19

x

Ball Mill 2

Motor Rated Power = Twin 5,250 kW [7,040 HP]
Power available at shell = 10,343 kW [13,870 HP]
Drawn Power at Shell = 9,177 kW [12,307 HP]
Dimensions = 22´Ø x 38´ EGL [6.7 m Ø x 11.6 m]
Speed = 13.0 RPM = 77.8 % critical
Filling = 33.0 % v/v total, 33.0 % v/v balls

Liner effective thickness 6.00 inches (0.500 feet)
Effective dimensions = 21.00´Ø x 38.00´ EGL
Critical speed is at 16.7 RPM
Ore density 3.08 tonnes/m^3
Charge density 5.29 tonnes/m^3
Grinding ball density 7.55 tonnes/m^3
Power at the DCS = 9,559 kW [12,819 HP]
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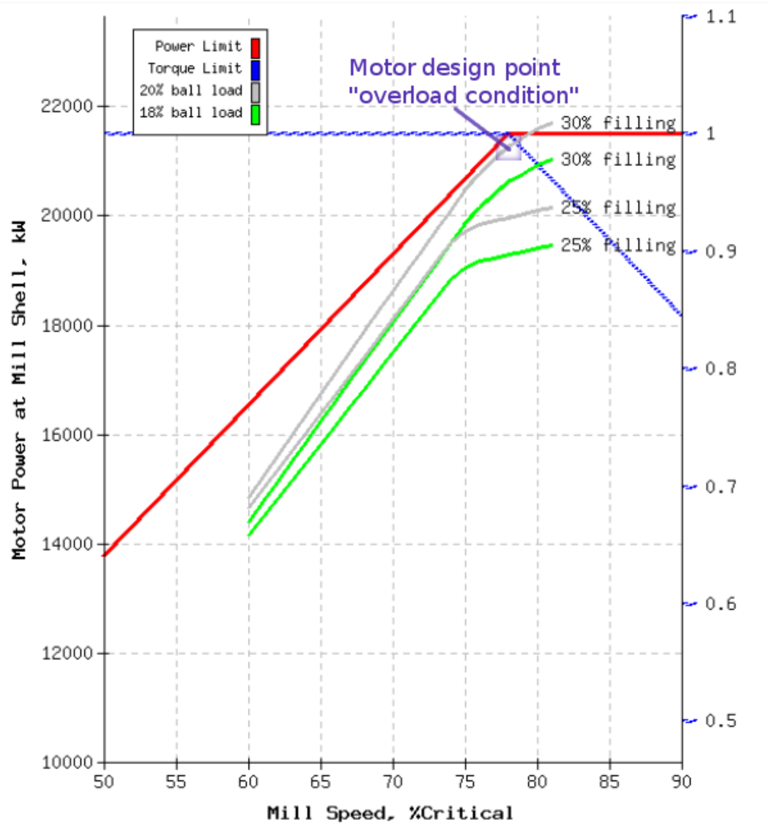
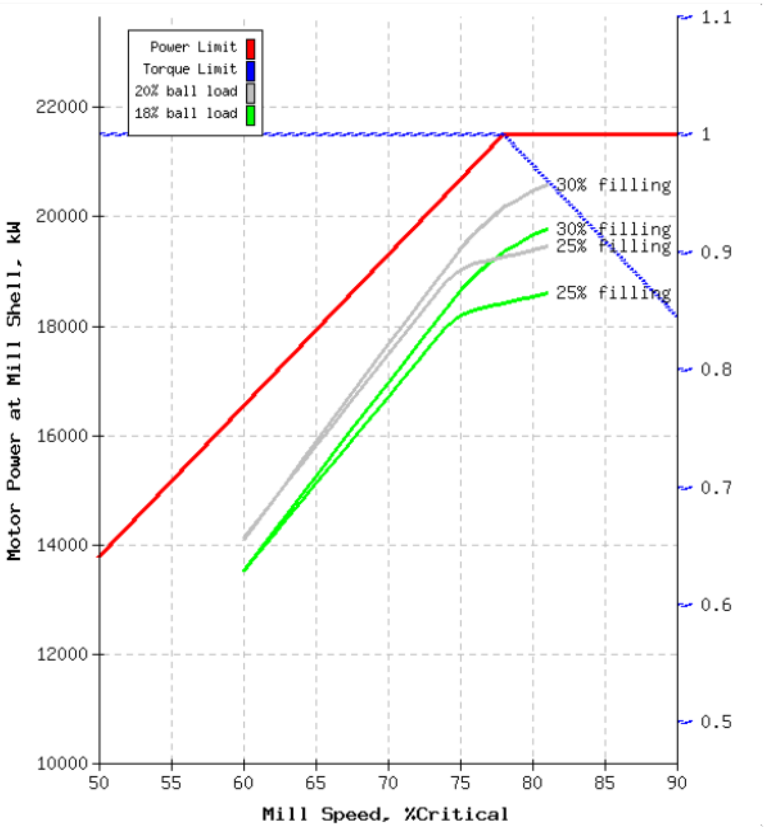
Predicted draw for overflow mill: 9,177 kW
280 Name: bm22x38

Case Study, 21.5 MW SAG

- Density 4.0 t/m³

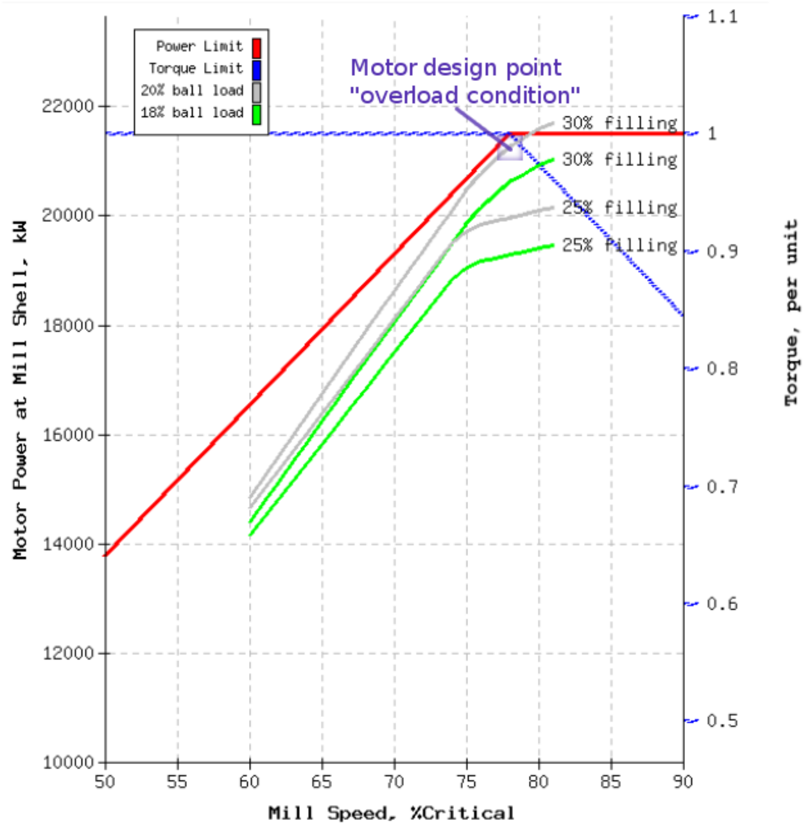


- Density 3.17 t/m³

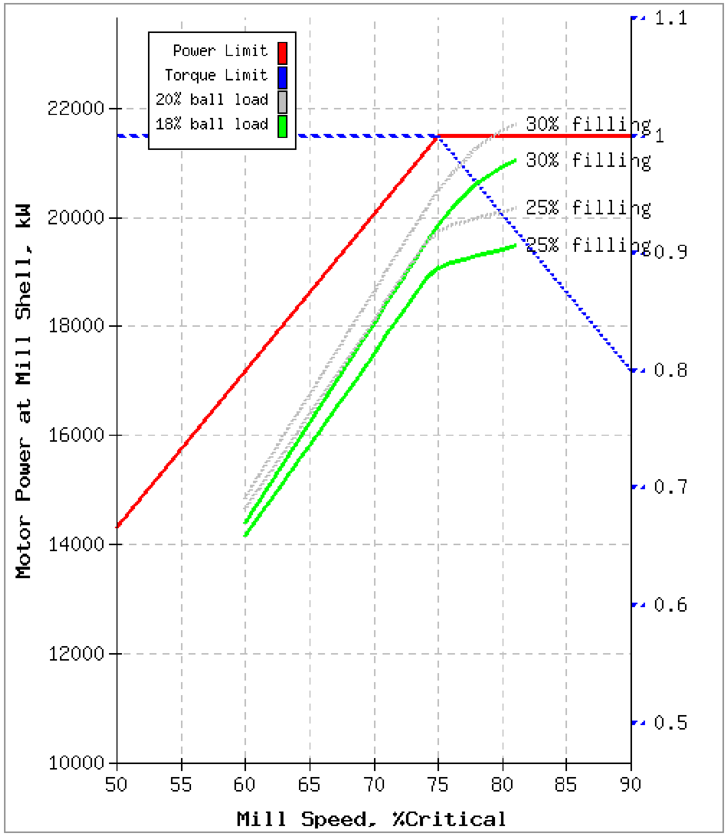


Case Study, Design Speed

- 78% of critical



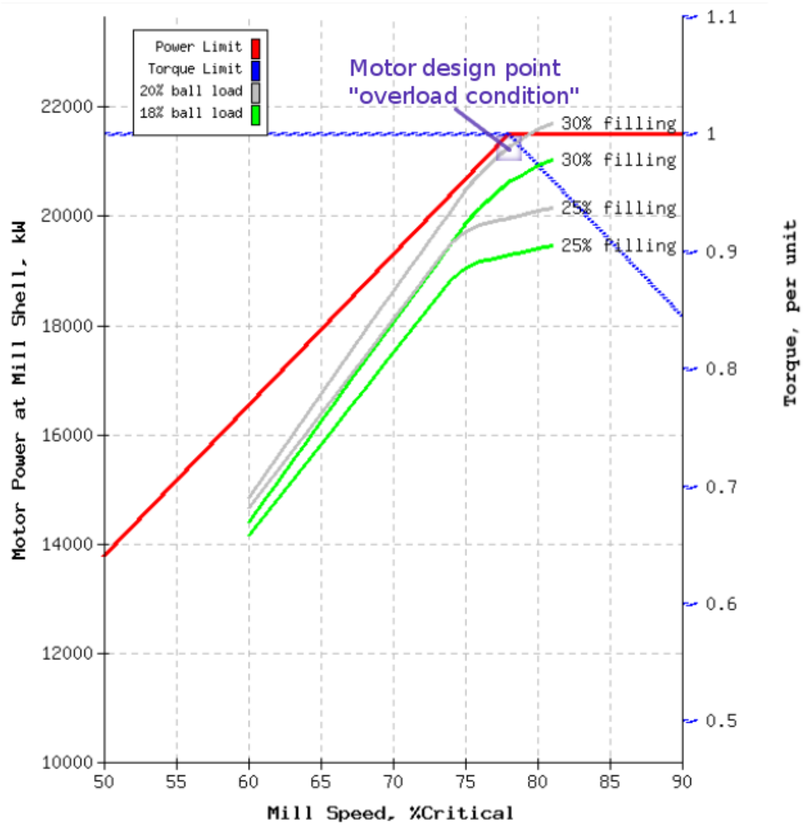
- 75% of critical



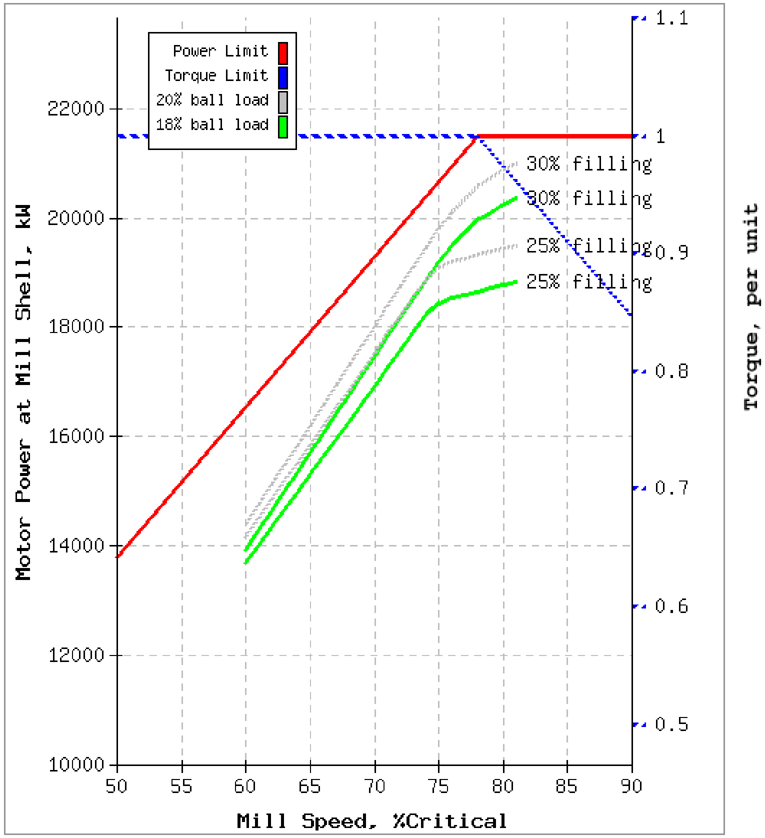
Case Study, Liners

(based on change in mill volume, does not consider charge motion)

- Worn (75 mm)



- New (150 mm)



Conclusion

- Size grinding mills for nominal operating conditions (throughput targets)
- Size motors for “overload” conditions that may reasonably be encountered
  - High ball charge, volumetric filling
  - High density ore
  - Worn liners