Tumbling Mill Critical Speed and Operating Speed

Critical speed of a ball, rod or SAG mill from its diameter and the ball size, the operating speed at a fraction of critical, shell speed and charge release angle.

Method: Wills and Finch; Wills' Mineral Processing Technology; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Mill diameter inside the liners	4.1200	m
Largest ball or rod diameter	64.000	mm
Operating speed as a fraction of critical	71.700	%

Calculated results

Parameter	Value	Unit
Critical speed	20.999	rpm
Operating speed	15.056	rpm
Angle of release of the outer balls from the vertical	59.063	°
Shell peripheral speed	3.2480	m/s

Notes for this case

• Mills run at 50–90 % of critical: rod mills about 60–70 %, ball mills 70–80 % (Wills). The release angle is for the outer layer with no slip; lifters and slip change the real trajectory.

Formula and method

$$N_c = \frac{42.3}{\sqrt{D-d}}\ \text{rpm}, \quad \cos\alpha = \frac{(2\pi N/60)^2 (D-d)/2}{g}$$

Variables

D	Mill diameter inside the liners	m
d	Largest ball or rod diameter	m
N/N_c	Operating speed as a fraction of critical	-
N_c	Critical speed	1/s
N	Operating speed	1/s
α	Angle of release of the outer balls from the vertical	rad
v	Shell peripheral speed	m/s

Method and standards

Balance of weight and centrifugal force on the outer ball.

Assumptions and limits

- No slip at the liner.

References

• Wills and Finch
• Wills' Mineral Processing Technology
• 8th ed. (Butterworth-Heinemann, 2016)
• ch. 7
• eqs. 7.1-7.4
• Perry's Chemical Engineers' Handbook
• 9th ed.
• sec. 21

- eq. 21-143

Report details

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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

Results are for engineering estimation. Verify critical designs against the referenced standards and your own data.

This calculator online

https://calc.firecad.com/civil/mining-minerals/mill-critical-speed

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.