Rotary Kiln Residence Time and Degree of Filling

Material residence time in a rotary kiln by the US Bureau of Mines formula from length, diameter, slope, speed and repose angle, with hold-up and filling.

Method: Duda; Cement Data Book; ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Kiln length	99.974	m
Kiln inside diameter	3.0480	m
Kiln slope	2.6600	°
Kiln speed	1.3000	rpm
Angle of repose of the material	40.000	°
Constriction factor (1 for a straight kiln)	1.0000	
Material feed rate	60.000	t/h
Bulk density of the bed	1,400.0	kg/m³

Calculated results

Parameter	Value	Unit
Residence time	106.18	min
Material hold-up	106.18	t
Kiln internal volume	729.47	m³
Degree of filling	10.397	%

Notes for this case

• The Bureau of Mines formula treats the kiln as uniform; real material moves fastest in the calcining zone and slowest in the burning zone. Hold-up uses the feed rate throughout (no allowance for mass loss on calcination).

Formula and method

$$t = \frac{1.77\, L \sqrt{\Theta}\; F}{p\, d\, n} \quad (\text{min};\ L, d \text{ ft},\ p, \Theta \text{ degrees},\ n \text{ rpm}), \qquad f = \frac{\dot{m} t}{\rho_b V_k}$$

Variables

L	Kiln length	m
d	Kiln inside diameter	m
p	Kiln slope	rad
n	Kiln speed	1/s
Θ	Angle of repose of the material	rad
F	Constriction factor (1 for a straight kiln)	-
$\dot{m}$	Material feed rate	kg/s
ρ_b	Bulk density of the bed	kg/m³
t	Residence time	s
M	Material hold-up	kg
V_k	Kiln internal volume	m³
f	Degree of filling	-

Method and standards

US Bureau of Mines formula.

Assumptions and limits

- Free-flowing bed, no dams.

References

- Duda
- Cement Data Book
- Vol. 1
- 3rd ed. (Bauverlag / Macdonald and Evans, 1985)
- secs. 19.1.1 and 19.1.5 (US Bureau of Mines formula)
- Boateng
- Rotary Kilns: Transport Phenomena and Transport Processes (Elsevier, 2008)
- ch. 3 (bed residence time)

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/chemical/cement/rotary-kiln-residence-filling

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.