Centrifuge Sigma Factor and Clarifying Capacity

Sigma factor (equivalent settling area) of a tubular-bowl or disc-stack centrifuge and the flow it can clarify for a given settling velocity (Perry's sec. 18).

Method: Perry's Chemical Engineers' Handbook; 9th ed. (McGraw-Hill, 2019); ...

Input parameters

Unit system: SI

Parameter	Value	Unit
Centrifuge	Disc stack	
Speed	6,000.0	rpm
Inner radius (liquid surface or disc inner)	50.000	mm
Outer radius (bowl or disc outer)	150.00	mm
Bowl length (tubular)	0.75000	m
Number of discs	100.00	
Disc half-angle from the axis	45.000	°
Particle settling velocity under gravity	1.0000e-07	m/s

Calculated results

Parameter	Value	Unit
Sigma factor (equivalent area)	27,128	m²
Clarifying capacity at the 50 % cut, Q = 2 v_g Σ	19.532	m³/h
G-force at the outer radius	6,038.5	

Notes for this case

- Use Σ to scale between machines: $Q_2/Q_1 = \Sigma_2/\Sigma_1$ for the same feed; real machines reach 40–70 % of the ideal.

Formula and method

$$\Sigma_{tube} = \frac{\pi L \omega^2 (r_2^2 - r_1^2)}{g \ln\left[2r_2^2/(r_1^2 + r_2^2)\right]}, \quad \Sigma_{disc} = \frac{2\pi(z-1)\,\omega^2 (r_2^3 - r_1^3)}{3g \tan\theta}, \quad Q = 2 v_g \Sigma$$

Variables

type	Centrifuge	-
N	Speed	1/s
r_1	Inner radius (liquid surface or disc inner)	m
r_2	Outer radius (bowl or disc outer)	m
L	Bowl length (tubular)	m
z	Number of discs	-
θ	Disc half-angle from the axis	rad
v_g	Particle settling velocity under gravity	m/s
Σ	Sigma factor (equivalent area)	m²
Q	Clarifying capacity at the 50 % cut, Q = 2 v_g Σ	m³/s
ω	Angular speed, 2πN	rad/s
g	Standard gravity, 9.806 65	m/s²
$\omega^2 r_2/g$	G-force at the outer radius	-

Method and standards

Ambler's sigma theory as in Perry's Chemical Engineers' Handbook, 9th ed., sec. 18, Eqs. 18-116 to 18-119 (p. 18-103). Σ is defined

as Q/(2 v_g) for the particle size recovered at 50 %. For a straight bowl this gives Eq. 18-117 with $\ln[2r_2^2/(r_1^2 + r_2^2)]$; for a disc stack Eq. 18-119 with z − 1 spaces between the discs.

Assumptions and limits

- Stokes settling; ideal flow.
- Q is for the particle size recovered at 50 %. Older texts use $\ln(r_2/r_1)$ with Q = v_g Σ for complete capture of that size, which gives a different Σ: use one convention throughout when scaling between machines.

References

• Perry's Chemical Engineers' Handbook
• 9th ed. (McGraw-Hill, 2019)
• sec. 18 (centrifuges): sigma theory for tubular and disc centrifuges

Report details

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

This calculator online

https://calc.firecad.com/chemical/unit-operations/centrifuge-sigma-factor

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