Agitator Scale-Up: Constant Power per Volume or Tip Speed

Speed and power of a geometrically similar larger agitator by constant power per unit volume or constant tip speed, for turbulent mixing.

Method: Turbulent agitation P = N_p ρN³D⁵ with geometric similarity (McCabe, Smith and Harriott)

Input parameters

Unit system: SI

Parameter	Value	Unit
Small impeller diameter	0.15000	m
Small impeller speed	300.00	rpm
Small agitator power	0.050000	kW
Large impeller diameter	0.90000	m
Scale-up rule	Constant power per volume (N ∝ D^−2/3)	

Calculated results

Parameter	Value	Unit
Large impeller speed	90.856	rpm
Large agitator power	10.800	kW
Power per volume ratio	1.00000	

Notes for this case

- Geometric similarity and turbulent flow (constant power number) assumed.

Formula and method

$$N_2 = N_1 \left(\frac{D_1}{D_2}\right)^{2/3} \text{ or } N_1 \frac{D_1}{D_2}, \quad P_2 = P_1 \left(\frac{N_2}{N_1}\right)^3 \left(\frac{D_2}{D_1}\right)^5$$

Variables

D_1	Small impeller diameter	m
N_1	Small impeller speed	1/s
P_1	Small agitator power	W
D_2	Large impeller diameter	m
rule	Scale-up rule	-
N_2	Large impeller speed	1/s
P_2	Large agitator power	W
$\frac{P_2/V_2}{P_1/V_1}$	Power per volume ratio	-

Method and standards

Geometric similarity with a constant power number in turbulent flow, so P ∝ N³D⁵ and V ∝ D³; the speed follows from the chosen rule (constant P/V gives N ∝ D^−2/3, constant tip speed N ∝ D^−1).

Assumptions and limits

- Turbulent, geometrically similar.

References

- Turbulent agitation P = N_p ρN³D⁵ with geometric similarity (McCabe, Smith and Harriott)

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/reactors/agitator-scale-up

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Reopens the calculator with the inputs of this report.