Vertical Turbine Flocculator: Stage Volume, Power, Speed and G

Stage volume and size, water power for a velocity gradient G, impeller speed from the power number, pumping rate and circulation time of a turbine flocculator.

Input parameters

Unit system: SI

Parameter	Value	Unit
Plant flow	75,000	m^3/d
Parallel trains	4.0000	
Stages in series per train	4.0000	
Total flocculation time	20.000	min
Velocity gradient in this stage	40.000	1/s
Impeller diameter (about 0.45 of the equivalent tank diameter)	2.0000	m
Impeller power number (pitched foil 0.2–0.3, pitched blade 1.3)	0.25000	
Impeller pumping number (foil about 0.5)	0.50000	
Water dynamic viscosity (10 °C 1.31 mPa·s, 20 °C 1.00)	1.3100	mPa·s
Water density	999.70	kg/m^3

Calculated results

Parameter	Value	Unit
Stage volume	65.104	m^3
Side of a cubic stage	4.0229	m
Equivalent tank diameter	4.5393	m
Suggested impeller diameter	2.0427	m
Water power	136.46	W
Impeller speed	15.447	rpm
Tip speed	1.6176	m/s
Impeller pumping rate	1.0298	m^3/s
Circulation time	63.222	s
Gt for this stage	12,000	

Notes for this case

• A cubic stage is assumed for the size. Typical practice: G 80–100 s^{-1} in the first stage tapering to 20–40 s^{-1}, total Gt 10^4–10^5, speed 10–30 rpm, tip speed below about 2–3 m/s.

Formula and method

$$P = G^2 \mu V, \quad N = \left(\frac{P}{N_p \rho D^5} \right)^{1/3}$$

$$Q_p = N_Q N D^3, \quad t_c = \frac{V}{Q_p}, \quad T_e = \sqrt{\frac{4 A_{plan}}{\pi}}$$

Variables

Q	Plant flow	m³/s
n_t	Parallel trains	-
n_s	Stages in series per train	-
t	Total flocculation time	s
G	Velocity gradient in this stage	1/s
D	Impeller diameter (about 0.45 of the equivalent tank diameter)	m
N_p	Impeller power number (pitched foil 0.2–0.3, pitched blade 1.3)	-
N_Q	Impeller pumping number (foil about 0.5)	-
μ	Water dynamic viscosity (10 °C 1.31 mPa·s, 20 °C 1.00)	Pa·s
ρ	Water density	kg/m³
V	Stage volume	m³
L	Side of a cubic stage	m
T_e	Equivalent tank diameter	m
$0.45T_e$	Suggested impeller diameter	m
P	Water power	W
N	Impeller speed	rad/s
v_{tip}	Tip speed	m/s
Q_p	Impeller pumping rate	m³/s
t_c	Circulation time	s
Gt	Gt for this stage	-

Method and standards

Camp–Stein velocity gradient with the impeller power number relation.

Assumptions and limits

- Fully turbulent impeller (constant power number); the cubic stage is a sizing assumption.

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

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Reopens the calculator with the inputs of this report.