Horizontal Paddle Wheel Flocculator: Power and Shaft Speed

Water power for a target G and the paddle shaft speed from paddle board area, radii and drag coefficient for a horizontal-shaft paddle wheel flocculator stage.

Input parameters

Unit system: SI

Parameter	Value	Unit
Plant flow	150,000	m³/d
Parallel trains	2.0000	
Stages in series per train	5.0000	
Total flocculation time	20.000	min
Velocity gradient in this stage	20.000	1/s
Paddle wheels on the shaft in the stage	2.0000	
Boards at each radius per wheel (arms)	4.0000	
Board width	0.15000	m
Board length	2.9700	m
Radius to the outer edge of the inner board	0.67000	m
Radius to the outer edge of the middle board (0 = none)	1.3300	m
Radius to the outer edge of the outer board (0 = none)	2.0000	m
Drag coefficient (1.5 for long boards, l/b > 20 about 1.9)	1.5000	
Paddle velocity relative to the water	75.000	%
Water dynamic viscosity (10 °C 1.31 mPa·s, 20 °C 1.00)	1.3100	mPa·s
Water density	999.70	kg/m³

Calculated results

Parameter	Value	Unit
Stage volume	208.33	m³
Water power for the G	109.17	W
Board area at each radius	3.5640	m²
Shaft speed	2.0837	rpm
Outer board speed	0.42004	m/s
Gt for this stage	4,800.0	

Notes for this case

- Board velocities are taken at the board centreline (edge radius minus half the width) and reduced by the relative-velocity factor for the water turning with the paddles. Outer board speeds of 0.15–0.6 m/s are usual.

Formula and method

$$P = G^2 \mu V = \frac{C_D A_p \rho}{2} \sum_i v_{p,i}^3, \quad v_{p,i} = k \omega r_i$$

$$N = \frac{60}{2\pi}\left[\frac{2P}{C_D A_p \rho k^3 \sum r_i^3}\right]^{1/3}$$

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
n_w	Paddle wheels on the shaft in the stage	-
n_a	Boards at each radius per wheel (arms)	-
b	Board width	m
l	Board length	m
r_1	Radius to the outer edge of the inner board	m
r_2	Radius to the outer edge of the middle board (0 = none)	m
r_3	Radius to the outer edge of the outer board (0 = none)	m
C_D	Drag coefficient (1.5 for long boards, l/b > 20 about 1.9)	-
k	Paddle velocity relative to the water	-
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
P	Water power for the G	W
A_p	Board area at each radius	m²
N	Shaft speed	rad/s
v_{tip}	Outer board speed	m/s
Gt	Gt for this stage	-

Method and standards

Drag power of paddle boards related to the Camp–Stein velocity gradient.

Assumptions and limits

- Boards at each radius of equal size; drag coefficient from the board aspect ratio.

Report details

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

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