Optimum Wind Blade Chord, Twist and Tip Loss at a Radius

Chord, relative wind angle, section pitch, twist, solidity and Prandtl tip-loss factor of an optimum rotor with wake rotation at one radial station.

Method: Optimum rotor with wake rotation; Prandtl tip-loss factor

Input parameters

Unit system: SI

Parameter	Value	Unit
Design tip speed ratio	7.0000	
Radial station	50.000	%
Number of blades	3.0000	
Design lift coefficient	1.0000	
Design angle of attack	7.0000	°
Rotor radius	40.000	m

Calculated results

Parameter	Value	Unit
Local speed ratio	3.5000	
Angle of relative wind	10.630	°
Chord	2.8755	m
Chord over radius	0.071888	
Section pitch angle φ − α	3.6303	°
Twist relative to the tip	5.2102	°
Local solidity Bc/(2πr)	0.068648	
Prandtl tip-loss factor	0.99981	

Notes for this case

• Optimum rotor with wake rotation and no drag: φ = (2/3)tan⁻¹(1/λ_r), c = 8πr(1 − cos φ)/(BC_l). The Prandtl factor F shows how much the tip loss reduces the local loading; design codes iterate BEM with F and drag.

Formula and method

$$\varphi = \frac{2}{3}\tan^{-1}\frac{1}{\lambda_r}, \quad c = \frac{8\pi r}{BC_l}(1-\cos\varphi), \quad F = \frac{2}{\pi}\cos^{-1}\left[\exp\left(-\frac{B/2\,(1-r/R)}{(r/R)\sin\varphi}\right)\right]$$

Variables

λ	Design tip speed ratio	-
r/R	Radial station	-
B	Number of blades	-
C_l	Design lift coefficient	-
α	Design angle of attack	rad
R	Rotor radius	m
λ_r	Local speed ratio	-
φ	Angle of relative wind	rad
c	Chord	m
c/R	Chord over radius	-

θ_p	Section pitch angle φ − α	rad
θ_T	Twist relative to the tip	rad
\sigma'	Local solidity Bc/(2πr)	-
F	Prandtl tip-loss factor	-

Method and standards

Optimum rotor blade geometry.

Assumptions and limits

- No drag, ideal optimum loading; one radial station.

References

Optimum rotor with wake rotation; Prandtl tip-loss factor

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/environmental/wind-power/wind-blade-optimum-chord-twist

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.