Maximum Power Coefficient with Wake Rotation (Glauert)

Maximum power coefficient of an ideal rotor including wake rotation as a function of tip speed ratio, from Glauert's optimum, compared with the Betz limit.

Method: Glauert optimum rotor with wake rotation

Input parameters

Unit system: SI

Parameter	Value	Unit
Tip speed ratio	3.0000	

Calculated results

Parameter	Value	Unit
Maximum power coefficient	0.54540	
Axial induction at the tip	0.33075	
Fraction of the Betz limit	92.036	%
Tangential induction at the tip	0.024018	

Notes for this case

• Glauert's optimum rotor: each annulus runs at λ_r² = (1 − a)(1 − 4a)²/(1 − 3a) and a′ = (1 − 3a)/(4a − 1); C_P,max = (24/λ²)∫ [(1 − a)(1 − 2a)(1 − 4a)/(1 − 3a)]² da from 0.25 to a_2 (Simpson's rule). Drag, tip loss and finite blade number lower real values further.

Formula and method

$$C_{P,max} = \frac{24}{\lambda^2}\int_{0.25}^{a_2}\left[\frac{(1-a)(1-2a)(1-4a)}{1-3a}\right]^2 da, \quad \lambda^2 = \frac{(1-a_2)(1-4a_2)^2}{1-3a_2}$$

Variables

λ	Tip speed ratio	-
$C_{P,max}$	Maximum power coefficient	-
a_2	Axial induction at the tip	-
$C_P/C_{P,Betz}$	Fraction of the Betz limit	-
a'_{tip}	Tangential induction at the tip	-

Method and standards

Glauert optimum rotor.

Assumptions and limits

- Ideal rotor: infinite blades, no drag.

References

Glauert optimum rotor with wake rotation

Report details

Report reference	FCC-535F-XTCV (the same inputs always give the same reference)
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Release checks	3 reference cases of this calculator, computed independently, are checked on every release

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-cp-max-wake-rotation

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.