Centrifugal Compressor Impeller: Pressure Ratio, Eye Angles, Tip Depth

Temperature rise, pressure ratio and power of a centrifugal compressor from tip speed, slip and power input factors, with eye vane angles and impeller tip depth.

Input parameters

Unit system: SI

Parameter	Value	Unit
Power input factor	1.0400	
Slip factor	88.000	%
Rotational speed	90,000	rpm
Impeller tip diameter	0.080000	m
Eye tip diameter	0.050000	m
Eye root (hub) diameter	0.015000	m
Air mass flow	1,440.0	kg/h
Inlet stagnation temperature	26.850	°C
Inlet stagnation pressure	1.0000	bar
Isentropic efficiency	75.000	%
Radial velocity at the tip (0 = equal to the eye axial velocity)	0	m/s
Share of the total loss in the impeller	50.000	%
Specific heat	1.0050	kJ/(kg·K)
Ratio of specific heats	1.4000	

Calculated results

Parameter	Value	Unit
Impeller tip speed	376.99	m/s
Stagnation temperature rise	129.42	K
Pressure ratio	2.6675	
Power	52.028	kW
Axial velocity at the eye	258.93	m/s
Vane inlet angle at the eye root (from tangential)	74.731	°
Vane inlet angle at the eye tip	47.698	°
Relative Mach number at the eye tip	1.0693	
Static pressure at the impeller tip	1.3732	bar
Impeller channel depth at the tip	4.3869	mm

Notes for this case

- Radial vanes, axial inlet (no prewhirl), axial velocity uniform across the eye and found by iterating the continuity equation with static density. The impeller tip depth assumes the chosen share of the total loss occurs in the impeller.

Formula and method

$$U = \pi D_2 N, \quad T_{03} - T_{01} = \frac{\psi \sigma U^2}{c_p}, \quad \frac{p_{03}}{p_{01}} = \left[1 + \frac{\eta_c (T_{03} - T_{01})}{T_{01}}\right]^{\gamma/(\gamma-1)}$$

$$\dot{m} = \rho_1 A_1 C_{a1}, \quad \alpha = \tan^{-1} \frac{C_{a1}}{U_{eye}}, \quad b_2 = \frac{\dot{m}}{\rho_2 C_{r2} \pi D_2}$$

Variables

ψ	Power input factor	-
σ	Slip factor	-
N	Rotational speed	rad/s
D_2	Impeller tip diameter	m
D_{et}	Eye tip diameter	m
D_{er}	Eye root (hub) diameter	m
$\dot{m}$	Air mass flow	kg/s
T_{01}	Inlet stagnation temperature	K
p_{01}	Inlet stagnation pressure	Pa
η_c	Isentropic efficiency	-
C_{r2}	Radial velocity at the tip (0 = equal to the eye axial velocity)	m/s
f_{imp}	Share of the total loss in the impeller	-
c_p	Specific heat	J/(kg·K)
γ	Ratio of specific heats	-
U	Impeller tip speed	m/s
$T_{03} - T_{01}$	Stagnation temperature rise	K
p_{03}/p_{01}	Pressure ratio	-
P	Power	W
C_{a1}	Axial velocity at the eye	m/s
α_{root}	Vane inlet angle at the eye root (from tangential)	rad
α_{tip}	Vane inlet angle at the eye tip	rad
$M_{rel,tip}$	Relative Mach number at the eye tip	-
p_2	Static pressure at the impeller tip	Pa
b_2	Impeller channel depth at the tip	m

Method and standards

Centrifugal compressor work and continuity at eye and tip.

Assumptions and limits

- Radial-vaned impeller, axial inlet, perfect gas with constant c_p.

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.