Polytropic and Isentropic Efficiency of Compressors and Turbines

Converts polytropic (small-stage) efficiency to the overall isentropic efficiency for a compressor or turbine at a pressure ratio, with the temperature ratio.

Input parameters

Unit system: SI

Parameter	Value	Unit
Machine	Compressor	
Pressure ratio (greater than 1)	4.0000	
Polytropic efficiency	88.000	%
Ratio of specific heats	1.4000	
Inlet temperature	14.850	°C

Calculated results

Parameter	Value	Unit
Polytropic exponent term	0.32468	
Temperature ratio	1.5685	
Outlet temperature	451.72	K
Equivalent isentropic efficiency	85.493	%

Notes for this case

- For a compressor the isentropic efficiency falls below the polytropic value as the pressure ratio rises (the reheat of each stage raises the work of the next); for a turbine it rises above it.

Formula and method

$$\text{compressor}: \quad \frac{n-1}{n} = \frac{1}{\eta_\infty}\frac{\gamma-1}{\gamma}, \quad \eta_s = \frac{r^{(\gamma-1)/\gamma}-1}{r^{(n-1)/n}-1}$$

$$\text{turbine}: \quad \frac{n-1}{n} = \eta_\infty \frac{\gamma-1}{\gamma}, \quad \eta_s = \frac{1-r^{-(n-1)/n}}{1-r^{-(\gamma-1)/\gamma}}$$

Variables

$\mathrm{machine}$	Machine	-
r	Pressure ratio (greater than 1)	-
η_∞	Polytropic efficiency	-
γ	Ratio of specific heats	-
T_1	Inlet temperature	K
$(n-1)/n$	Polytropic exponent term	-
T_2/T_1	Temperature ratio	-
T_2	Outlet temperature	K
η_s	Equivalent isentropic efficiency	-

Method and standards

Polytropic (small-stage) efficiency relations.

Assumptions and limits

- Ideal gas with constant γ.

Report details

Report reference	FCC-HKCA-GXK0 (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/boilers-power-plant/gas-turbines-combined-cycle/polytropic-isentropic-efficiency

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.