Gas Turbine (Brayton) Cycle Efficiency and Work

Compressor and turbine outlet temperatures, net work, thermal efficiency, back-work ratio and power of a simple gas turbine cycle with real component efficiencies.

Method: Air-standard Brayton cycle (Çengel and Boles, Thermodynamics: An Engineering Approach, ch. 9)

Input parameters

Unit system: SI

Parameter	Value	Unit
Compressor inlet temperature	15.000	°C
Pressure ratio	15.000	
Turbine inlet temperature	1,200.0	°C
Compressor isentropic efficiency	86.000	%
Turbine isentropic efficiency	89.000	%
Specific heat of the air and gas	1.0050	kJ/(kg·K)
Ratio of specific heats	1.4000	
Air mass flow	360,000	kg/h

Calculated results

Parameter	Value	Unit
Compressor outlet temperature	406.29	°C
Turbine outlet (exhaust) temperature	493.70	°C
Compressor work	393.25	kJ/kg
Turbine work	709.84	kJ/kg
Net work	316.59	kJ/kg
Heat added	797.68	kJ/kg
Thermal efficiency	39.689	%
Ideal (isentropic) cycle efficiency	53.871	%
Back-work ratio w_c / w_t	55.400	%
Net power	31.659	MW

Notes for this case

- Air-standard cycle with constant cp and γ; fuel mass, real gas properties and pressure losses are left out.

Formula and method

$$T_2 = T_1 + \frac{T_1\left(r_p^{(\gamma-1)/\gamma} - 1\right)}{\eta_c}, \quad T_4 = T_3 - \eta_t T_3\left(1 - r_p^{-(\gamma-1)/\gamma}\right)$$

$$w_c = c_p(T_2 - T_1), \quad w_t = c_p(T_3 - T_4), \quad \eta = \frac{w_t - w_c}{c_p(T_3 - T_2)}$$

$$\eta_{ideal} = 1 - r_p^{-(\gamma-1)/\gamma}$$

Variables

T_1	Compressor inlet temperature	K
r_p	Pressure ratio	-

T_3	Turbine inlet temperature	K
η_c	Compressor isentropic efficiency	-
η_t	Turbine isentropic efficiency	-
c_p	Specific heat of the air and gas	J/(kg·K)
γ	Ratio of specific heats	-
$\dot{m}$	Air mass flow	kg/s
T_2	Compressor outlet temperature	K
T_4	Turbine outlet (exhaust) temperature	K
w_c	Compressor work	J/kg
w_t	Turbine work	J/kg
w_{net}	Net work	J/kg
q_{in}	Heat added	J/kg
η	Thermal efficiency	-
η_{ideal}	Ideal (isentropic) cycle efficiency	-
BWR	Back-work ratio w_c / w_t	-
P	Net power	W

Method and standards

The air-standard Brayton cycle with constant specific heats: isentropic compression and expansion corrected by the component isentropic efficiencies, heat added at constant pressure.

Assumptions and limits

- Air-standard: no fuel mass, no pressure losses, constant cp and γ.
- No cooling air or blade cooling losses.
- One c_p and γ for air and hot gas: at 1 200 °C the gas has c_p about 1.15–1.2 kJ/(kg·K) and γ about 1.33, so a real machine differs materially. A note appears if c_p and γ imply a gas constant far from air.

References

• Air-standard Brayton cycle (Çengel and Boles, Thermodynamics: An Engineering Approach, ch. 9)

Report details

Report reference	FCC-38YZ-219H (the same inputs always give the same reference)
Generated	17 November 2026, 19:46 UTC
Calculator	Gas Turbine (Brayton) Cycle Efficiency and Work
Method last reviewed	12 November 2026
Software release	FireCAD Calc, release of 17 November 2026
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/turbines-cycles/brayton-cycle-efficiency

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Reopens the calculator with the inputs of this report.