Recuperated Gas Turbine Cycle Efficiency and Specific Work

Specific work, heat input and thermal efficiency of a simple gas turbine cycle with a recuperator of given effectiveness, compared with the same cycle unrecuperated.

Method: Air-standard Brayton cycle with recuperation

Input parameters

Unit system: SI

Parameter	Value	Unit
Compressor inlet temperature	15.000	°C
Overall pressure ratio	8.0000	
Turbine inlet temperature	1,100.0	°C
Compressor isentropic efficiency	85.000	%
Turbine isentropic efficiency	88.000	%
Mean specific heat	1.1000	kJ/(kg·K)
Heat capacity ratio	1.3600	
Recuperator effectiveness	85.000	%

Calculated results

Parameter	Value	Unit
Compressor outlet temperature	263.83	°C
Turbine exhaust temperature	588.49	°C
Air to combustor after recuperator	539.79	°C
Net specific work	288.95	kJ/kg
Thermal efficiency, recuperated	46.889	%
Thermal efficiency without recuperator	31.414	%

Notes for this case

• Air-standard cycle with constant c_p: the recuperator heats compressor air from T_2 towards the exhaust T_4, cutting fuel by c_p(T_5 − T_2) without changing net work (recuperator pressure losses neglected). It pays only at low pressure ratios where T_4 is well above T_2: microturbines and some marine units use r_p 4–10 with ε ≈ 0.85–0.9.

Formula and method

$$T_5 = T_2 + \varepsilon(T_4 - T_2), \quad \eta = \frac{c_p[(T_3 - T_4) - (T_2 - T_1)]}{c_p(T_3 - T_5)}$$

Variables

T_1	Compressor inlet temperature	K
r_p	Overall pressure ratio	-
T_3	Turbine inlet temperature	K
η_c	Compressor isentropic efficiency	-
η_t	Turbine isentropic efficiency	-
c_p	Mean specific heat	J/(kg·K)
γ	Heat capacity ratio	-
ε	Recuperator effectiveness	-
T_2	Compressor outlet temperature	K

T_4	Turbine exhaust temperature	K
T_5	Air to combustor after recuperator	K
w_{net}	Net specific work	J/kg
η	Thermal efficiency, recuperated	-
η_0	Thermal efficiency without recuperator	-

Method and standards

Recuperated cycle.

Assumptions and limits

- Constant c_p and γ; no pressure losses; same mass flow throughout.

References

Air-standard Brayton cycle with recuperation

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/boilers-power-plant/gas-turbines-combined-cycle/recuperated-gas-turbine-cycle

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.