Steam Turbine Power Output

Power of a back-pressure or condensing steam turbine from the steam flow, inlet conditions, exhaust pressure and efficiencies (IAPWS-IF97).

Method: IAPWS R7-97(2012) IF97; first law of thermodynamics (steady-flow energy equation)

Input parameters

Unit system: SI

Parameter	Value	Unit
Steam flow	10,000	kg/h
Inlet steam pressure (absolute)	45.000	bar
Inlet steam condition	Superheated at the temperature below	
Inlet steam temperature (superheated only)	400.00	°C
Exhaust pressure (absolute)	400.00	kPa
Turbine isentropic efficiency	75.000	%
Gearbox and generator efficiency	95.000	%

Calculated results

Parameter	Value	Unit
Electrical power	1,080.8	kW
Turbine shaft power	1,137.6	kW
Exhaust temperature	169.50	°C
Exhaust dryness (1 = dry or superheated)	100.00	%
Inlet enthalpy	3,205.6	kJ/kg
Exhaust enthalpy	2,796.0	kJ/kg
Isentropic exhaust enthalpy	2,659.5	kJ/kg

Formula and method

$$h_{2s} = h(p_2, s_1) \qquad h_2 = h_1 - \eta_i \left(h_1 - h_{2s}\right)$$

$$P_{sh} = \dot{m}_s \left(h_1 - h_2\right) \qquad P_{el} = \eta_g \, P_{sh} \qquad T_2,\ x_2 = f(p_2, h_2)$$

Variables

$\dot{m}_s$	steam flow	kg/s
p_1	inlet pressure, absolute	Pa
state	dry saturated or superheated inlet	–
T_1	inlet temperature (superheated)	K
p_2	exhaust pressure, absolute	Pa
η_i	turbine isentropic efficiency	–
η_g	gearbox and generator efficiency	–
P_{el}	electrical power	W
P_{sh}	turbine shaft power	W
T_2	exhaust temperature	K
x_2	exhaust dryness fraction	–
h_1	inlet enthalpy	J/kg
h_2	actual exhaust enthalpy	J/kg

h_{2s}	isentropic exhaust enthalpy	J/kg
s_1	inlet entropy	J/(kg·K)

Method and standards

Steady-flow energy balance across the turbine with the isentropic efficiency definition; inlet and exhaust states, including wet steam, from FireCAD's IAPWS-IF97 (backward equations h(p,s) and T(p,h)).

Assumptions and limits

- Single expansion, no extraction; steady flow; kinetic and potential energy changes neglected.
- Efficiencies are constant at the given load.

References

- IAPWS R7-97(2012) IF97
- first law of thermodynamics (steady-flow energy equation)

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.