Back-Pressure Turbine: Power vs Exhaust Pressure

Power of a back-pressure turbine at two exhaust pressures for the same inlet steam (IF97), and the power gained per bar lower exhaust pressure.

Method: Isentropic expansion with efficiency; IAPWS-IF97

Input parameters

Unit system: SI

Parameter	Value	Unit
Steam flow	100.00	t/h
Inlet pressure (absolute)	67.000	bar
Inlet temperature	495.00	°C
Exhaust pressure A (absolute)	2.5000	bar
Exhaust pressure B (absolute)	2.0000	bar
Isentropic efficiency	78.000	%
Gearbox and generator efficiency	96.000	%

Calculated results

Parameter	Value	Unit
Power at exhaust A	16.312	MW
Power at exhaust B	17.097	MW
Power difference B − A	785.89	kW
Power per bar of exhaust pressure	1,571.8	kW

Notes for this case

- Lower exhaust pressure gives power but less evaporator temperature difference in the process: balance the two.

Formula and method

$$P = \dot{m}\,\eta_s\,[h_1 - h(p_e, s_1)]\,\eta_g, \quad \Delta P = P_B - P_A, \quad \frac{\Delta P}{\Delta p} = \frac{P_B - P_A}{(p_{e,A} - p_{e,B})/1\ \text{bar}}$$

Variables

$\dot{m}$	Steam flow	kg/s
p_1	Inlet pressure (absolute)	Pa
T_1	Inlet temperature	K
h_1 s_1	inlet enthalpy and entropy (IF97)	J/kg, J/(kg·K)
$h(p_e, s_1)$	isentropic exhaust enthalpy	J/kg
$p_{e,A}$	Exhaust pressure A (absolute)	Pa
$p_{e,B}$	Exhaust pressure B (absolute)	Pa
η_s	Isentropic efficiency	-
η_g	Gearbox and generator efficiency	-
P_A	Power at exhaust A	W
P_B	Power at exhaust B	W
ΔP	Power difference B − A	W
$\Delta P/\Delta p$	Power per bar of exhaust pressure	W

Method and standards

Expansion from the inlet state to each exhaust pressure at the inlet entropy (IAPWS-IF97), scaled by the isentropic efficiency and the gearbox and generator efficiency; the difference is expressed per bar of exhaust pressure. A note appears if an actual exhaust state is wet.

Assumptions and limits

- Constant efficiency.
- The inlet must be superheated (or supercritical) steam; an inlet below saturation is rejected.

References

Isentropic expansion with efficiency; IAPWS-IF97

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/steam-turbines/back-pressure-sensitivity

Open this case on calc.firecad.com →

Reopens the calculator with the inputs of this report.