

Thermodynamic Devices Cheat Sheet

Nozzles, turbines, compressors, throttles, heat exchangers

ENGINEERING
CHEAT SHEET

Key equations

Quantity	Equation	Notes
Ideal gas law	$P V = n R T$	Most accurate at high T and low P
Ideal gas internal energy / enthalpy	$\Delta u = c_v(T_2 - T_1) \quad \Delta h = c_p(T_2 - T_1)$	Constant specific heats; valid only over small ΔT
Mass balance (steady)	$\Sigma \dot{m}_{in} = \Sigma \dot{m}_{out}$	Control volume = open system
Energy balance (steady flow)	$\dot{Q} - \dot{W} = \Sigma \dot{m}_{out}(h + V^2/2 + g z) - \Sigma \dot{m}_{in}(h + V^2/2 + g z)$	Form used throughout; the article shows it as an image
Adiabatic nozzle / diffuser	$h_1 + V_1^2/2 = h_2 + V_2^2/2$	Nozzle: V up, P down. Diffuser: V down, P up
Nozzle efficiency	$\eta_n = (V_2^2/2) / (V_{2s}^2/2)$	Actual vs isentropic exit kinetic energy
Turbine efficiency	$\eta_T = (h_1 - h_2) / (h_1 - h_{2s})$	h_{2s} = isentropic exit enthalpy
Compressor / pump efficiency	$\eta_c = (h_{2s} - h_1) / (h_2 - h_1)$	Actual work input is larger than ideal
Throttle / valve	$h_1 = h_2$	$W = 0, Q = 0$, negligible ΔKE and ΔPE
Heat exchanger (no mixing, adiabatic)	$\dot{m}_h(h_{h,in} - h_{h,out}) = \dot{m}_c(h_{c,out} - h_{c,in})$	Hot-side heat loss equals cold-side gain

Key takeaways

- A control volume lets mass and energy cross its boundary. Typical open systems: nozzles, turbines, compressors, heat exchangers.
- Nozzle accelerates the flow by converting enthalpy into kinetic energy; a diffuser does the reverse.
- Turbines produce work; compressors (gas) and pumps (liquid) consume it; a fan or blower moves air with little pressure rise.
- Real devices are less efficient than the isentropic ideal because of friction and heat loss, so always compare against the same inlet state and exit pressure.
- Throttling drops pressure at constant enthalpy and usually cools the fluid. It is the expansion step in refrigeration and air-conditioning cycles.
- Boilers, evaporators, condensers and combustors are heat-exchange devices; heat engines produce work, while heat pumps, refrigerators and A/C use work to move heat.
- The article works two examples: an adiabatic steam nozzle (600 kPa, 500 K, 120 m/s in, area ratio 2:1, 380 m/s out) and a steam turbine (12 MPa, 625 °C in; 10 kPa, $x = 0.95$ out). Their solutions are shown as images there.