Isoentropic efficiencies of steady-flow devices

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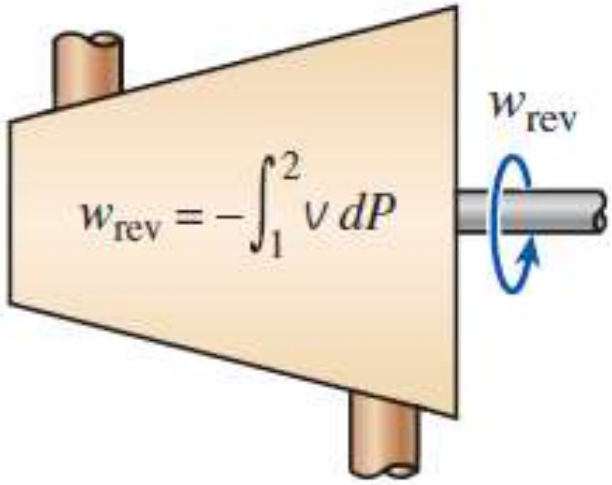
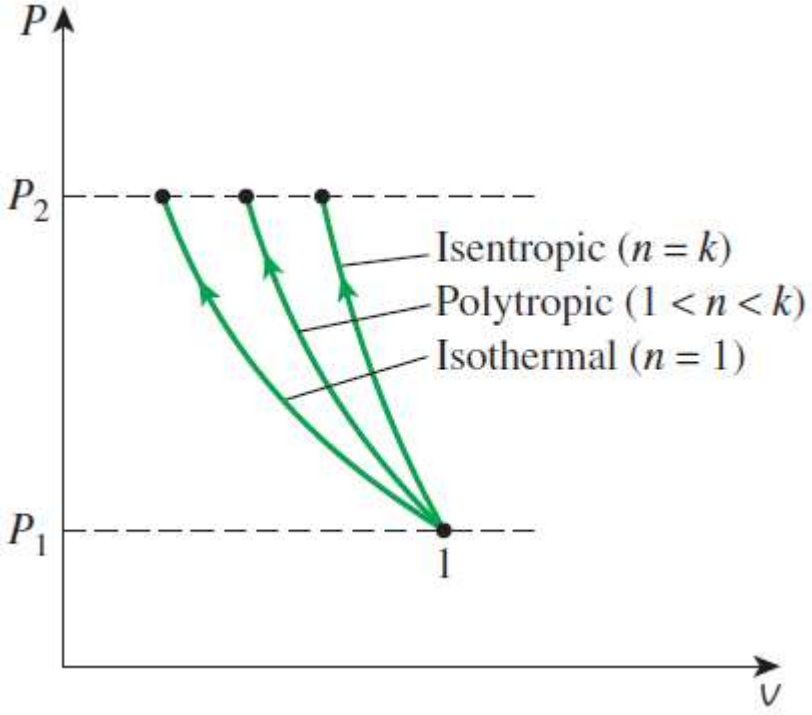
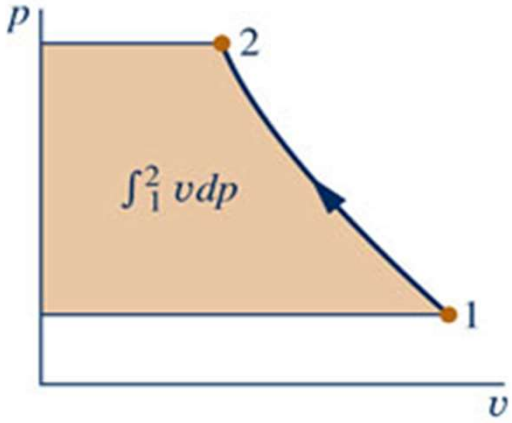
Previously: Work in Reversible Steady Flow

Work Input $w_{rev,in} = \int_1^2 v\,dP + \Delta ke + \Delta pe$

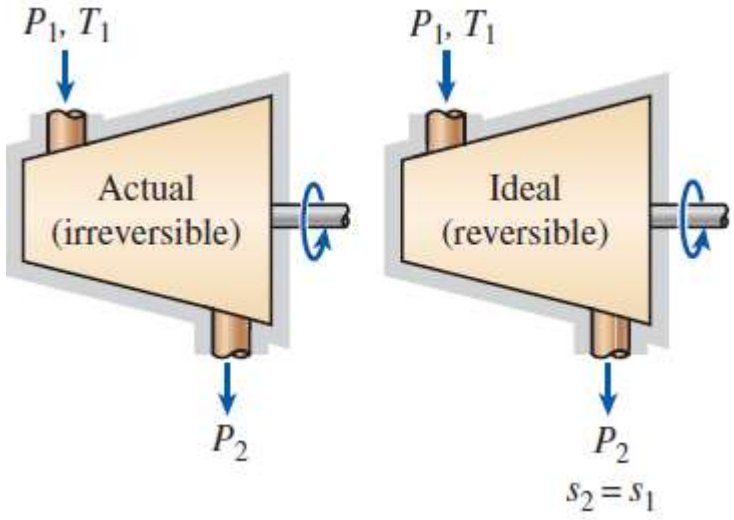






Figs-TD: Cengel & Boles; TD: Moran, Shapiro, Boetner & Bailey

How to compare real against ideal efficiency?

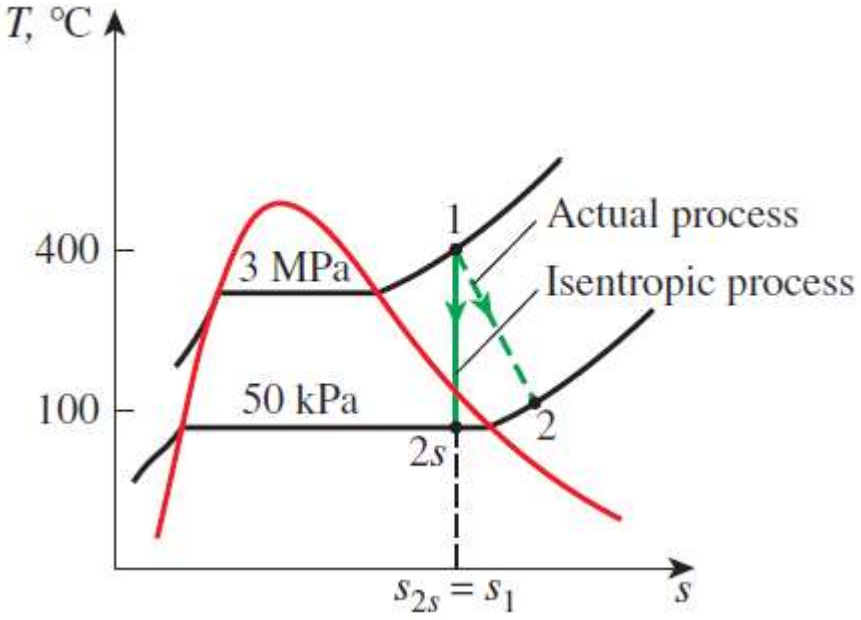


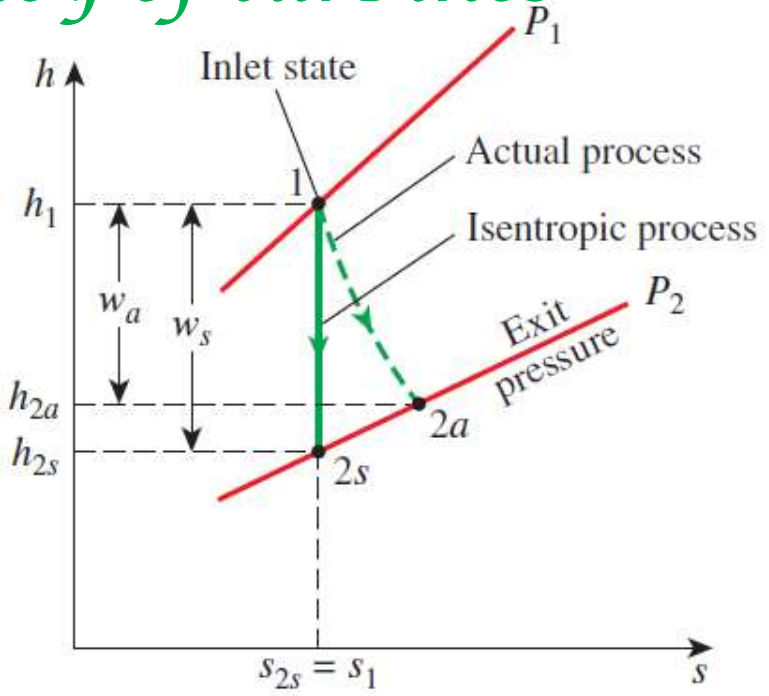
- Carnot cycle & irreversibilities
- How to extend such measures to flow devices?
- Adiabatic operation and isoentropic analysis

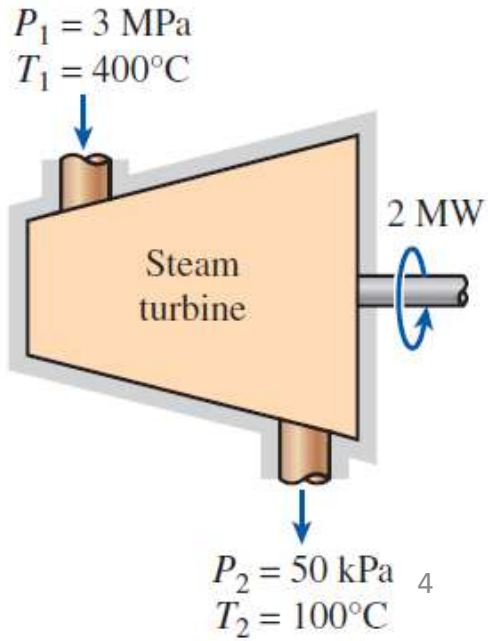
Isoentropic efficiency of turbines

$$\eta_T = \frac{\text{Actual turbine work}}{\text{Isentropic turbine work}} = \frac{w_a}{w_s}$$

$$\eta_T \cong \frac{h_1 - h_{2a}}{h_1 - h_{2s}}$$







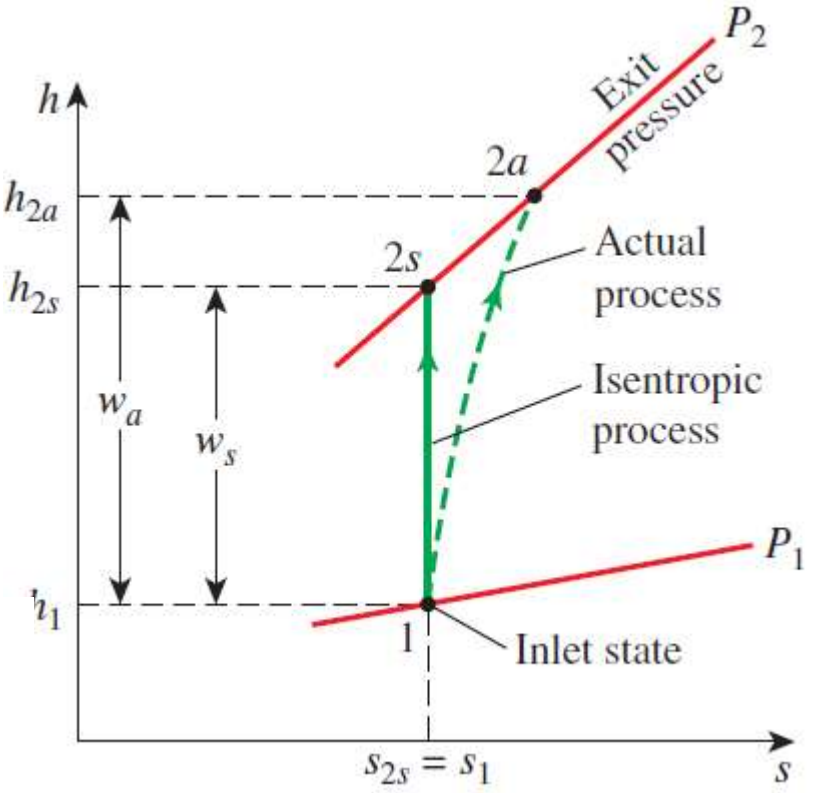
- η_T ~ 90% (70%) for large (small) turbines

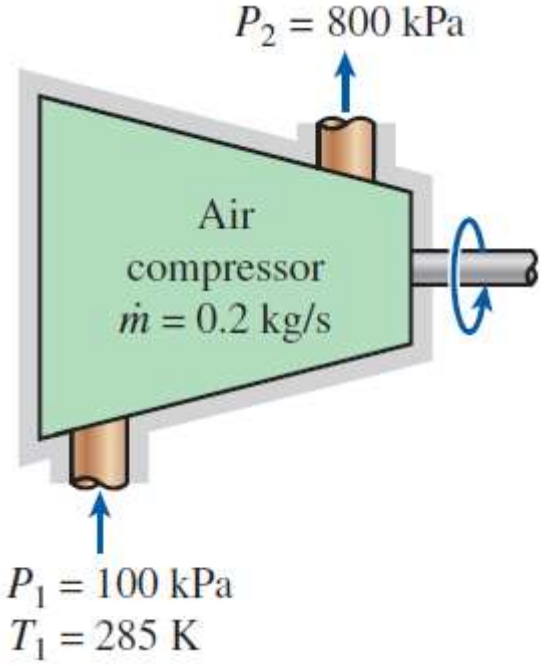
Isoentropic efficiency of compressors & pumps

$$\eta_C = \frac{\text{Isentropic compressor work}}{\text{Actual compressor work}} = \frac{w_s}{w_a}$$

$$\eta_C \cong \frac{h_{2s} - h_1}{h_{2a} - h_1}$$

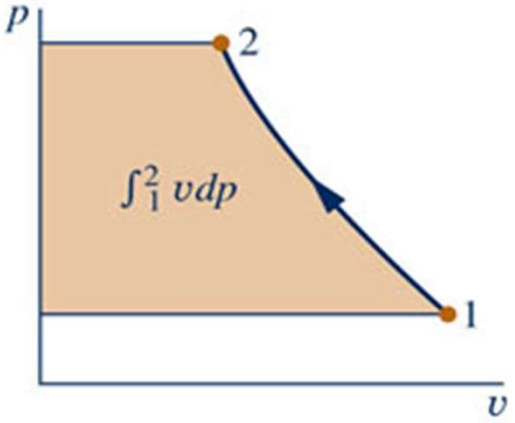
$$\eta_P = \frac{w_s}{w_a} = \frac{v(P_2 - P_1)}{h_{2a} - h_1}$$ For a pump



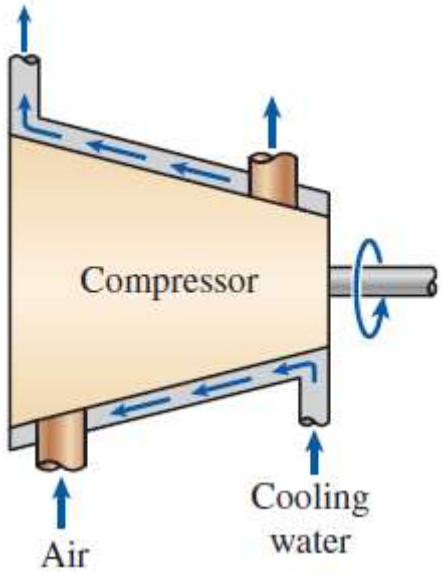


- η_C ~ 85%

Cooling to decrease specific volume

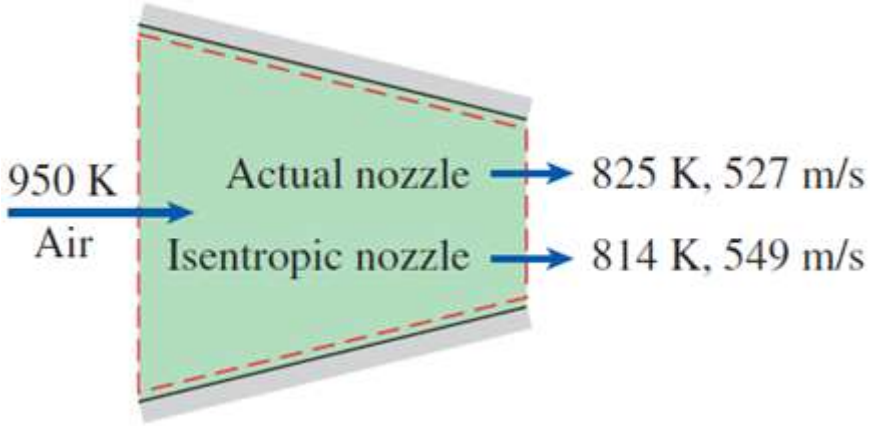


$$\eta_C = \frac{w_t}{w_a}$$ Isothermal efficiency based on reversible isothermal work w_t



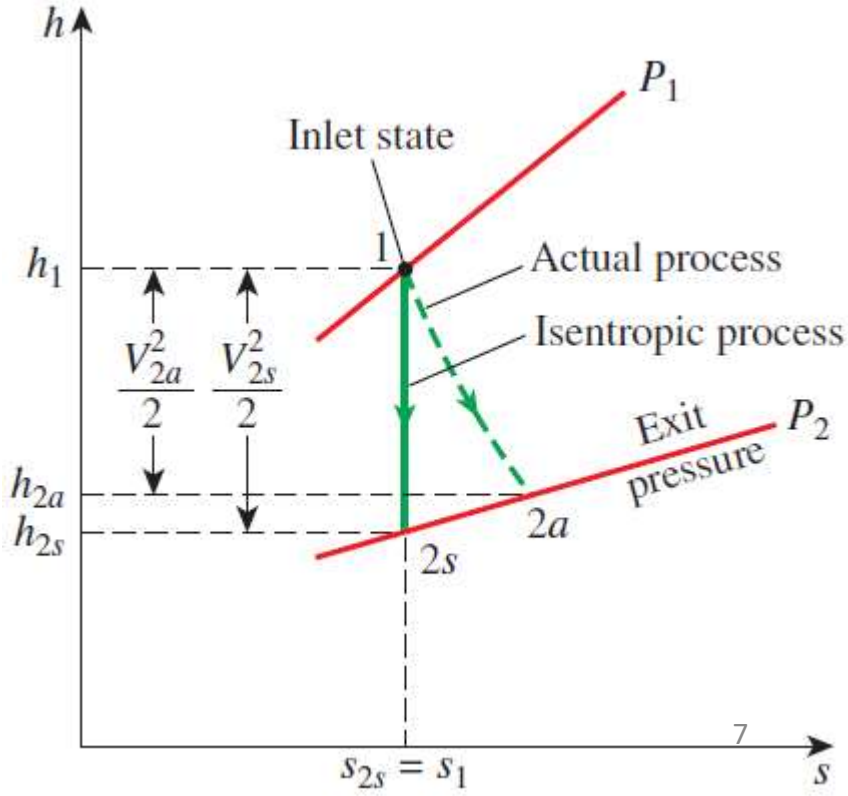
Isoentropic efficiency of nozzles

$$\eta_N = \frac{\text{Actual KE at nozzle exit}}{\text{Isentropic KE at nozzle exit}} = \frac{V_{2a}^2}{V_{2s}^2}$$



$$h_1 = h_{2a} + \frac{V_{2a}^2}{2}$$

$$\eta_T \cong \frac{h_1 - h_{2a}}{h_1 - h_{2s}}$$



- $\eta_N \sim 90\%$

What's next?

- Entropy balance & generation