16.050 Thermal Energy

Quiz #1 – Fall 2002

Do all three problems. All problems count the same.

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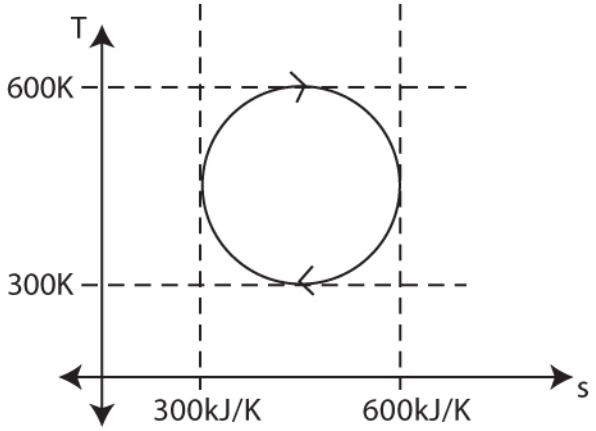
1. A reversible cycle plots as a perfect circle on a *T-S* diagram with maximum and minimum temperatures 600 K and 300 K and a maximum and minimum entropy of 600 kJ/K and 300 kJ/K.

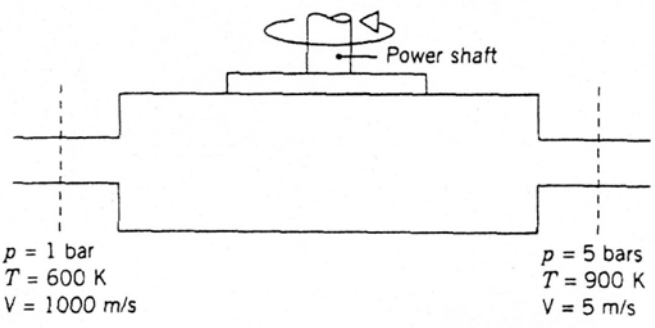


   a) What is the net work of this cycle?

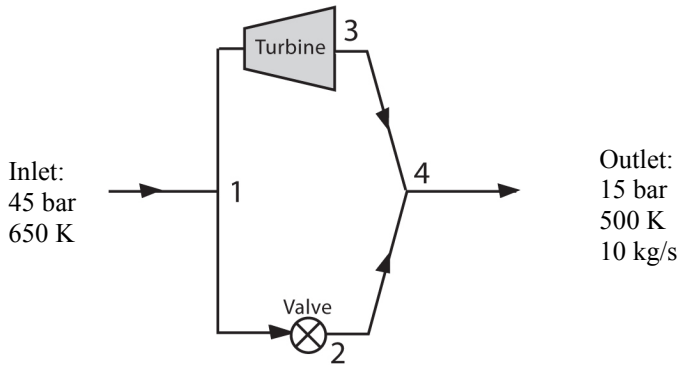
   b) Indicate the path in the cycle along which heat is rejected. How do you know? (A sentence or two is required, perhaps bolstered by an equation).

   c) What is the thermodynamic efficiency of this cycle?

2. The following device operates at steady-state and is well insulated. Air enters at one location and exits at another with a mass flow rate of 10 kg/s. Assuming ideal gas behavior and negligible potential energy effects, determine the direction of the air flow and the direction of the power flow. Determine the power in kW. Assume cp=1000 J/kgK for air. (Hint: it might be useful to initially assume directions of the different energy fluxes and then to check for consistency.)



3. The figure below shows a throttling valve in parallel with a turbine having an isentropic efficiency of 90%. Both turbine and throttle operate at steady state and heat transfer with the surroundings and kinetic and potential energy effects can be neglected. You may assume the working fluid has a constant cp=1 kJ/kgK and a ratio of specific heats of γ=1.4.



a) Sketch the throttling process from state 1 to state 2 in a T-s diagram. Indicate the curves of pressures p_1 and p_2 in the diagram.

b) Determine the pressure drop $\Delta p = p_1 - p_2$ across the throttle and the temperature at throttle exit T_2.

c) Sketch the expansion through the turbine on the same T-s diagram and indicate the curve of pressure p_3.

d) Determine the temperature at the turbine exit T_3.

e) Sketch processes 3 to 4 and 2 to 4 in the same T-s diagram. Explain in a sentence or two what happens during these processes.

f) What is the mass flow rate through the turbine in kg/s? (Hint: you may want to define an appropriate control volume that includes the turbine exit flow, the throttle exit flow and the flow at the system outlet.)

g) What is the power developed by the turbine?