Homework #5

MEMS 0051 - Introduction to Thermodynamics

Assigned February 16th, 2018
Due: February 23rd, 2018

Problem #1

Use you tables to determine the change in enthalpy (h_2-h_1) for each of the following cases:

a) Concrete cooled from 40°C to 20°C
b) Butane heated up from 25°C to 55°C
c) Argon gas heated from 20°C to 50°C
d) Superheated water vapor at 200 [kPa] cooled from 300°C to 200°C
e) Saturated water at 100°C that goes from a quality of 0.4 to a quality of 0

Problem #2

Consider air that is heated from 300 K to 600 K.

a) Use the specific heats in Table A.5 to estimate the change in internal energy (u_2-u_1) and the change in enthalpy (h_2-h_1).
b) Use the tabulated values for air in Table A7.1 to determine the change in internal energy (u_2-u_1) and the change in enthalpy (h_2-h_1).
c) Compare your estimated values from part a) to the exact values in b). Do you think that it's okay to apply the specific heat formulas to estimate (u_2-u_1) and (h_2-h_1) for this process? Explain.

Problem #3

For each of the following devices, draw a schematic that labels and quantifies all of the energy flows ($\dot{W}$,$\dot{Q}_H$, $\dot{Q}_L$) between two thermal reservoirs (T_H,T_L). Then calculate the correct metric of performance (η, β, or β') for each device.

a) A heat engine that converts 800 [kW] of heat into 250 [kW] of power.
b) A refrigerator with a power input of 300 [kW] that rejects 1000 [kW] of heat to the environment.
c) A heat pump that takes in 500 [kW] of heat and outputs 700 [kW] of heat.

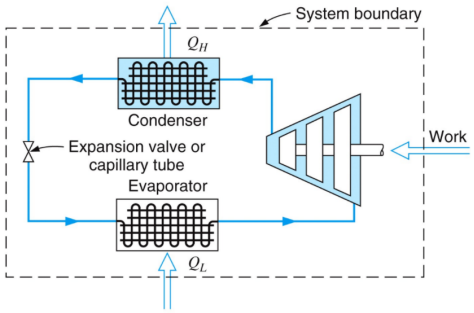
Problem #4

Do the following systems violate the 2nd Law of Thermodynamics? Why or why not? Hint: use the Kelvin-Planck Statement, the Clausius Statement, and/or Perpetual Motion Machines to explain your answers.

a) A system that transfers heat from a cold reservoir to a warm reservoir spontaneously.
b) A system that transfers heat from a cold reservoir to a warm reservoir with a power input.
c) A system that produces power by taking in heat and rejecting heat to a colder reservoir.
d) A system that produces power by taking in heat and not rejecting any heat.
e) A system that does work without any heat transfers.
f) A system that converts heat to work with 30% efficiency.

Problem #5

Consider the refrigeration cycle shown below, where a refrigerant cycles through a compressor, an evaporator, an expansion valve, and a condenser. The compressor requires an electrical input, the evaporator removes heat from the inside of the refrigerator, and the condenser rejects heat to the air in the room.



a) What are some sources of irreversibility in this cycle? List at least two.
b) What are some modifications you could make to this system to make it more reversible? Describe at least two modifications.