Homework #6

MEMS 0051 - Introduction to Thermodynamics

Assigned February 22nd, 2019
Due: March 1st, 2019

Problem #1

1. Calculate the Carnot efficiency of a heat engine operating between the following reservoir temperature combinations:
   a) T_H=500 [K]. T_L=250 [K]
   b) T_H=1,000[K]. T_L=300 [K]
   c) T_H=600 [K]. T_L=50 [K]
   d) T_H=205 [K]. T_L=105 [K]
2. Based on your previous calculations, how is Carnot efficiency affected by raising T_H? What about raising T_L?

Problem #2

Assume a cyclic heat engine extracts energy ($\dot{Q}_H$) from a hot temperature reservoir having a temperature of 350 [°C] and the machine. If heat is rejected from the same machine and a cold temperature reservoir ($\dot{Q}_L$) having a temperature of 30 [°C], what can be said about the possibility of the machine for the following cases?

a) $\dot{Q}_H$= 12 [kW], $\dot{Q}_L$= 6 [kW]
b) $\dot{Q}_H$= 45 [kW], $\dot{Q}_L$= 13 [kW]
c) $\dot{Q}_H$= 30 [kW], $\dot{Q}_L$= 5 [kW]
d) $\dot{Q}_H$= 2 [kW], $\dot{Q}_L$= 1 [kW]
e) $\dot{Q}_H$= 21 [kW], $\dot{Q}_L$= 8 [kW]

Problem #3

200 [g] of liquid water at 35 [°C] is put into ice trays and left in a refrigerator at atmospheric pressure. Said refrigerator works in a Carnot cycle between a cold temperature reservoir at -8 [°C] and a hot temperature reservoir at 35 [°C]. The refrigerator motor-compressor has a power rating of 800 [W]. Assuming the water is the only substance being cooled, how many seconds will it take to turn the water into ice? Assume a constant specific heat of 4.1855 [kJ/(kg K)].

Problem #4

Consider N_2 in a piston-cylinder undergoing a Carnot cycle between temperature reservoirs at 300 [K] and 1,000 [K]. The isothermal compression process results in the specific volume shrinking from 2.0 [m^3/kg] to 0.5 [m^3/kg]. You may treat this gas as <u>ideal</u>. Since u_2-u_1=$C_{\forall O}(T_2$-$T_1)$ isn't a good approximation at temperatures as high as 1,000 [K], use the tabulated values in Table A.8 to determine changes in internal energy.

a) Draw this cycle on a P-ν diagram. Label the low and high temperature isotherms, and also label the two given specific volumes.
b) Calculate the Carnot efficiency of this cycle.
c) Determine the heat added during the isothermal expansion (q_H) and the heat rejected during the isothermal compression (q_L).
d) Determine the changes in internal energy for the adiabatic expansion and the adiabatic compression processes.
e) Determine the net work done by this cycle. Shade the net work on your P-ν diagram.