Homework #7

MEMS 0051 - Introduction to Thermodynamics

Assigned February 28th, 2020
Due March 6th, 2020

Problem #1

In Matlab, plot the Carnot efficiency of a heat engine as a function of low- and high-temperature reservoir temperatures. The high-temperature reservoir temperature varies between 300 [K] and 1,400 [K]. The low-temperature reservoir has discrete temperatures of 253, 263, 273, 283, 293, 303, and 313 [K].

Problem #2

A piston-cylinder device contains 1 [kg] of water, which is undergoing a Carnot cycle. The water starts the isothermal expansion process with a quality of 25% and a pressure of 1,500 [kPa], and ends as a saturated vapor. The adiabatic expansion process is completed when the pressure reaches 100 [kPa] and the water exists at a quality of 84.9%. Determine:

a) The heat for each of the four processes;
b) the work for each of the four processes;
c) the thermal efficiency of the cycle.

Problem #3

A Carnot cycle, that uses 1 [kg] of air as the working fluid, has a thermal efficiency of 50%. If the heat transferred to the air during the isothermal expansion process is 50 [kJ], and the pressure at the beginning of this process is 700 [kPa], and the volume at the beginning of this process is 0.12 [m^3], determine:

a) The maximum and minimum temperatures of the cycle;
b) the volume at the end of the isothermal heat addition process;
c) the work for each of the four processes;
d) the heat for each of the four processes;

This problem is to be completed considering the specific heat of air as a i) constant value taken from Table A.5, ii) evaluated using the average temperate temperature, which is the arithmetic mean of the maximum and minimum temperature, from Table A.6 and iii) evaluated using the integral average of the specific heat using Table A.6.

Problem #4

Water vapor, which exists at 100 [kPa] and 400 [K], undergoes a process to a final state where the pressure is 500 [kPa] and the temperature is 900 [K]. Using Matlab, determine the change in specfic entropy via the following:

a) Using the superheate vapor tables;
b) using the specific heat listed in Table A.5;
c) using the specific heat, evaluated using an average temperature, as listed in Table A.6;
d) using the specific heat, evaluated via the integral average, as listed in Table A.6.

Problem #5

Using Matlab, calculate the change of specific entropy for a working fluid that enters a condenser as a saturated liquid and exits as a saturated vapor, at a temperature of -6.8 °C. Additionally, calculate the quantity of heat removed. The working fluids to be considered are:

a) Ammonia;
b) R-410a;
c) R-12;
d) R-134a using Table A.5;
e) R-134a using Table A.6;
f) R-134a using Table B.5.1.

Problem #6

You are quenching a 2,000 [kg] 304 stainless steel (SS) bar, which is initially at 1,120 °C. You are placing the SS bar in a tank of liquid, which has a volume of 8 [m^3] and an initial temperature of 300 [K]. Using Matlab, and Table A.3, determine the net change of entropy of the SS bar and liquid, considering the following liquids:

a) Water;
b) light oil;
c) glycerine.