Homework #4

MEMS 0051 - Introduction to Thermodynamics

Assigned February 1st, 2020
Due February 7th, 2020

Problem #1

A piston-cylinder device contains air at a pressure of 600 [kPa] and a temperature of 290 [K]. The initial volume is 0.1 [m^3]. A constant-pressure process produces 55 [kJ] of work done by the system.

(a) Determine the final temperature of the air.
(b) Determine the heat input.

Problem #2

Water contained in a piston-cylinder assembly has an initial temperature of 150 °C, a quality of 50% and an initial volume of 0.05 [m^3]. The pressure of the process is given as $P(\forall)=100 + C\forall^{0.5}$ kPa. Heat is transferred to the piston-cylinder until the final pressure reaches 600 [kPa].

(a) Determine the heat input.
(b) Plot this process on your P-ν and T-ν diagrams in Matlab.

Problem #3

A piston-cylinder device has two stops; a lower set and an upper set, that constrain the cylinder. When the piston is on the lower stops, the volume is 0.4 Liters. When the piston reaches the upper stops, the volume is 0.6 Liters. The piston-cylinder initially contains water at 100 [kPa] and a quality of 20%. The water is heated until it is completely transformed to steam. Additionally, the mass of the piston requires a pressure of 300 [kPa] to raise it. When the piston hits the upper stops:

(a) Determine the final pressure in the cylinder.
(b) Determine the heat input.
(c) Determine the work for the overall process.
(d) Plot this process on your P-ν and T-ν diagram in Matlab.
(e) Hint: there are 4 states. Think about the processes involved.

Problem #4

A piston-cylinder device contains 0.1 [kg] of air at a pressure of 100 [kPa] and a temperature of 400 [K] that undergoes an expansion process. The volume of the piston-cylinder device expands from 1 [m^3] to 3 [m^3] at a constant pressure of 2,000 [kPa]. Then, as the piston-cylinder device expands from 3 [m^3] to 5 [m^3], the pressure linearly decreases from 2,000 to 1,000 [kPa].

(a) Determine the heat input.
(b) Determine the work for the overall process.

Problem #5

For the following scenarios, determine the amount of heat transfer.

(a) Heating a 2 [kg], 0.1 [m] long copper bar from 25°C to 100°C.
(b) 1,000 [kg] of asphalt cooling from 50°C to 20°C.
(c) The heating of 1 [kg] of oxygen in a mass-less piston-cylinder from 300 to 1,500 K.
(d) A piston-cylinder containing 0.1695 [kg] of nitrogen at 150 [kPa] and 25°C that is isothermally compressed to 1.0 [MPa], which requires 20 [kJ] of work.