Textbook Reading 6.1-6.10

HW-27, HW-28, and HW-29 are based on previous homework problems. You do not need to repeat the analysis from the previous problems and you can use any needed results.

HW – 27(i) (See HW – 10)

Ammonia (m = 10 kg) contained inside a closed piston-cylinder device undergoes three processes.

Process 1 to 2: A constant pressure process from an absolute pressure of 20 bar and 40°C (State 1) until the volume increases to 0.42174 m^3 (State 2)

Process 2 to 3: A constant volume process to saturated vapor (State 3)

Process 3 to 4: A constant temperature process to an absolute pressure of 20 bar (State 4)

(a) Calculate the entropy generation for each process, in kJ/K. Assume that the cylinder wall in contact with the fluid remains at a constant boundary temperature of 100ºC.

(b) Show the three processes on *T*-*s* diagram relative to the vapor dome and the appropriate lines of constant pressure for the four states. Label states and identify process directions with arrows.

For ammonia: P_{critical} = 113 bar and T_{critical} = 132°C.

HW – 27(ii) (See HW – 12(i))

A closed, rigid tank is divided into two sections by a partition. One section initially contains air at an absolute pressure of 5 bar, an absolute temperature of 500 K, and a volume of 0.2 m^3 while the other section is perfectly evacuated (State 1). The partition is removed and air expands to fill the entire tank at an absolute pressure of 1.25 bar and a volume of 0.4 m^3 (State 2). Consider constant specific heat c_p = 1.017 kJ/kg-K for air. Assume that the tank wall in contact with air remains at a constant boundary temperature of 300 K.

(a) Determine the entropy generation during the process, in kJ/K.

(b) Show the process on *T*-*s* diagram relative to the appropriate lines of constant pressure for the two states. Label states and identify process directions with arrows.

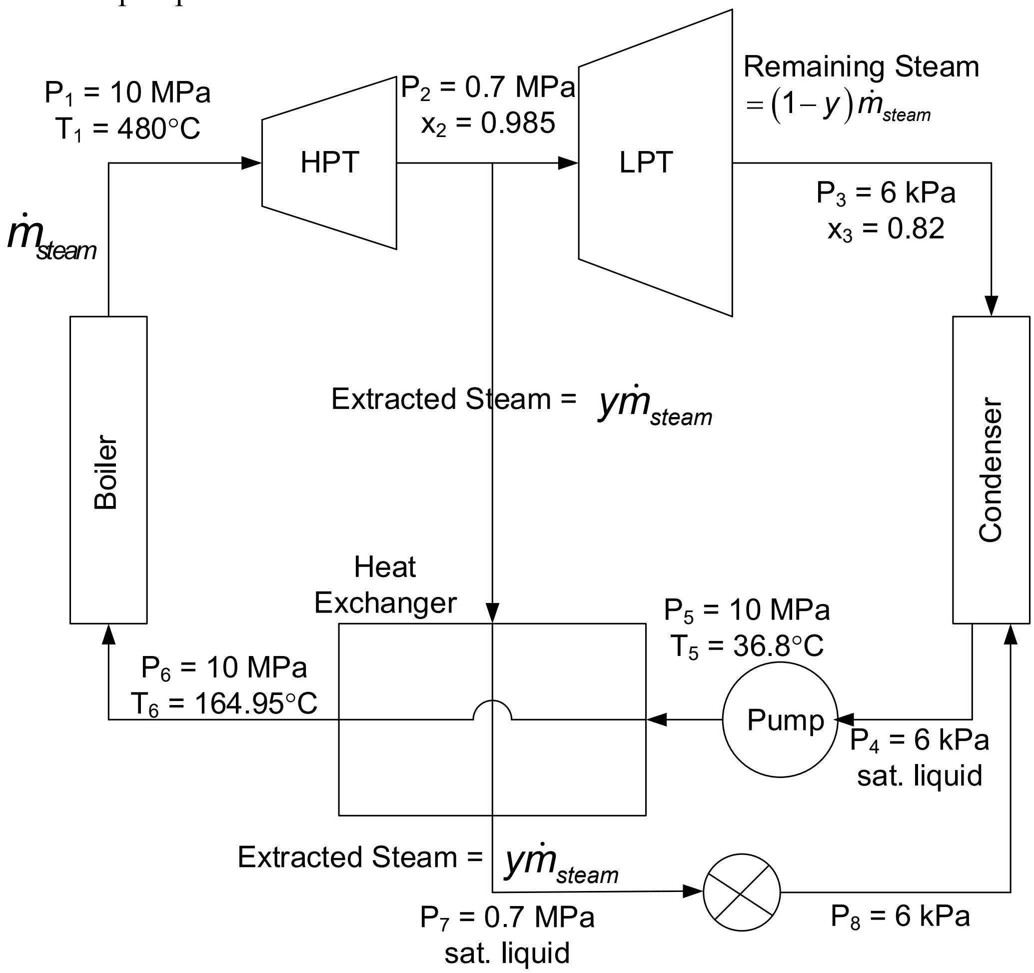
HW – 28(i) (See HW – 16(ii))

Saturated liquid-vapor mixture of water with quality of 93.2% at an absolute pressure of 0.08 bar (State 1) is cooled to saturated liquid at an absolute pressure of 0.08 bar (State 2) in a condenser (heat exchanger) operating at steady state in a thermal power plant. Mass flow rate of condensing stream is 3.4×10^5 kg/hr. A separate stream of cooling water enters the condenser at an absolute pressure of 1 bar and a temperature of 15°C (State 3) and exits with negligible pressure drop at a temperature of 35°C (State 4).

Calculate the rate of entropy generation for the condenser, in kW/K.

HW – 28(ii) (See HW-17)

A power cycle operating steadily is shown below. The boiler (a heat exchanger to boil liquid water) produces steam at an absolute pressure of 10 MPa and a temperature of 480°C (State 1). Steam leaving the boiler enters a high-pressure turbine (HPT) and expands to an absolute pressure of 0.7 MPa and a quality of 98.5% (State 2). A fraction of the steam (y) is extracted at State 2 and the remaining fraction of the steam (1 – y) at State 2 expands in a low-pressure turbine (LPT) to an absolute pressure of 6 kPa and a quality of 82% (State 3). Steam leaving the LPT is cooled in a condenser and exits as saturated liquid at an absolute pressure of 6 kPa (State 4). Saturated liquid water leaving from the condenser is pumped to an absolute pressure of 10 MPa and a temperature of 36.8°C (State 5) in a pump. Liquid leaving the pump (State 5) is heated using the extracted steam (State 2) in a rigid and well-insulated heat exchanger to an absolute pressure of 10 MPa and a temperature of 164.95°C (State 6) and is supplied to the boiler. Extracted steam (State 2) exits the heat exchanger as saturated liquid at an absolute pressure of 0.7 MPa (State 7) and is throttled to an absolute pressure of 6 kPa (State 8) feeding into the condenser. Assume that both turbines and pump are adiabatic.



(a) Find the specific entropy generation (per unit mass flow rate leaving the boiler) for the HPT and LPT, in kJ/kg-K.
(b) Calculate the specific entropy generation (per unit mass flow rate leaving the boiler) for the pump, in kJ/kg-K.
(c) Determine the specific entropy generation (per unit mass flow rate leaving the boiler) for the condenser, in kJ/kg-K. Assume a constant boundary temperature of 27°C for condenser heat transfer.
(d) Show the cycle on *T-s* diagram and the appropriate lines of constant pressure for all the states. Label states and identify process directions with arrows. For water: P_{critical} = 221 bar and T_{critical} = 374°C.

HW – 29 (See HW-20)

A rigid tank of volume 0.0189 m^3 initially contains a saturated liquid-vapor mixture of R-134a at 20°C with 90% liquid by mass in the mixture (State 1). A small leak develops at the top of the tank and saturated vapor R-134a slowly exits the tank until there is only saturated vapor at 20ºC left in the tank (State 2) when the leak is stopped. Assume that the tank wall in contact with the fluid remains at a constant boundary temperature of 27°C.

Determine the entropy generation during the process, in kJ/K.