King Mongkut's University of Technology Thonburi

First semester final exam — Academic year: 2007
MEE 231 Thermodynamics I — Mechanical Engineering
October 11, 2007 — Time: 13:00-16:00

Note:

1. There are total of 8 pages with 5 questions.
2. Write the answer in the available space.
3. Any textbooks, dictionaries and lecture notes are not allowed.
4. A calculator approved by the University is permitted.
5. There are total of 8 property tables.

Wishsanuruk Wechsatol
Surachai Bovornsethanan

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1. Answer the following problems, (10 points)

1.1 What is the Kelvin – Plank expression of the second law of thermodynamics?

1.2 What is the Clausius expression of the second law of Thermodynamics?

1.3 What is the difference between heat engine and heat pump?

1.4 The thermal efficiency of the heat engine cannot be 100%. How much the efficiency can be if the heat engine work between any T_H and T_L.

1.5 What are the processes that make up the Carnot cycle?

1.6 What are the two statements known as the Carnot principle?

1.7 What is the difference between first law efficiency and second law efficiency?

1.8 Show the energy equation for unsteady flow process?

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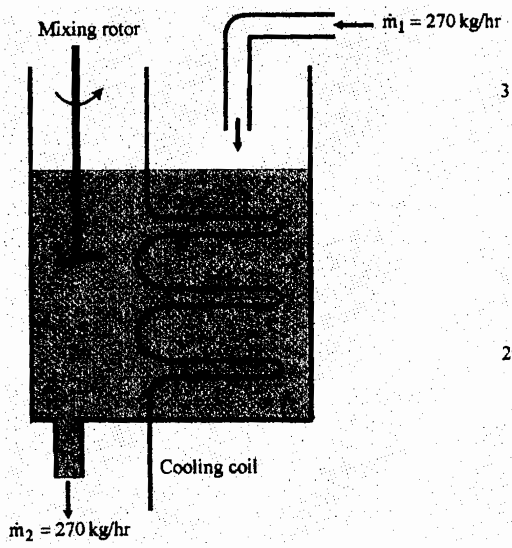
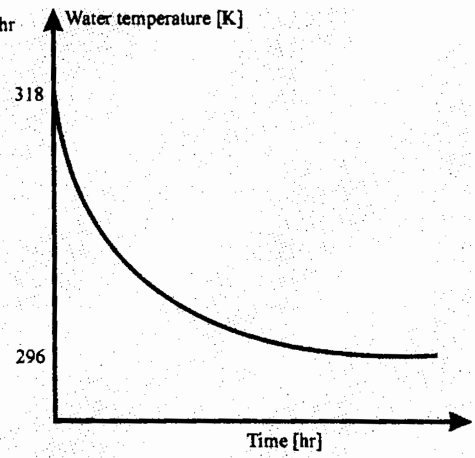
2. A tank containing 45 kg of liquid water initially at 45 °C has one inlet and one exit with equal mass flow rates. Liquid water enters at 45 °C and a mass flow rate of 270 kg/hr. A cooling coil immersed in the water removes energy at a rate of 7.6 kW. The water is well mixed by a paddle wheel so that the water temperature is uniform throughout. The power input to the water from the paddle wheel is 0.6 kW. The pressure at the inlet and exit are equal and all kinetic and potential energy effects can be ignored. Determine the variation of water temperature with time (in other words, find the equation that could predict the temperature of water at each point in times). (20 points)





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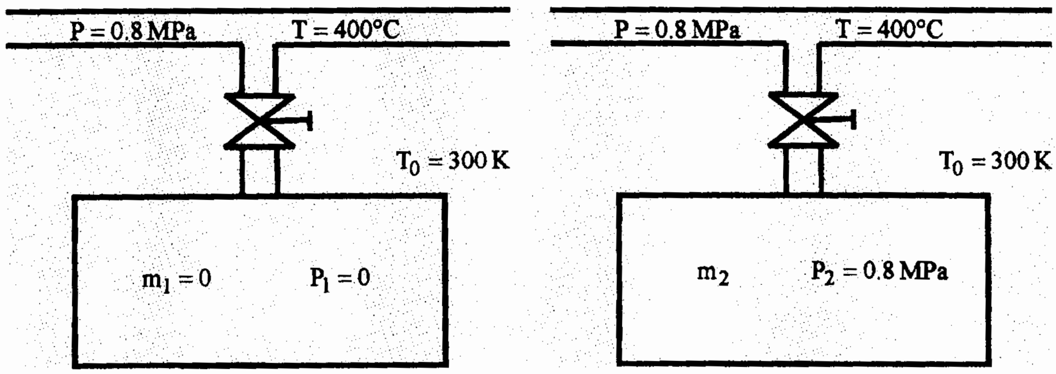
3. A tank initially contains very little water (this implies that $m_1 \approx u_1 \approx s_1 = 0$). The tank is attached to a steam line that is at 0.8 MPa and 400 °C. The valve connecting the tank and steam line is opened until the tank pressure reaches 0.8 MPa, and then the valve is closed. During the process there is a heat transfer of 1,000 kJ from the tank to the surroundings <u>for each kilogram of steam in the tank</u> $(Q_{out,\,1\text{-}2}/m_2)$ at the end of the process. Note that the surrounding temperature is at 300 K. Determine the final state in the tank (provide P_2 and T_2 or P_2 and x_2 as appropriate) and the generated entropy per unit mass (S_{gen}/m_2).
(20 points)



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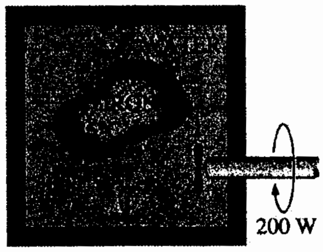
4. An iron block of unknown mass at 85 °C is dropped into an insulated tank that contains 100 L of water at 20 °C. At the same time, a paddle wheel driven by a 200-W motor is activated to stir the water. It is observed that thermal equilibrium is established after 20 min with a final temperature of 24 °C. Assuming the surroundings to be at 20 °C, determine (a) the mass of the iron block and (b) the exergy destroyed during this process. Given the density of water is constant at 997 kg/m^3 and the specific heat of water c is equal to 4.18 $kJ/kg\cdot K$, while the specific heat of the iron mass is equal to 0.45 $kJ/kg\cdot K$. (20 points)



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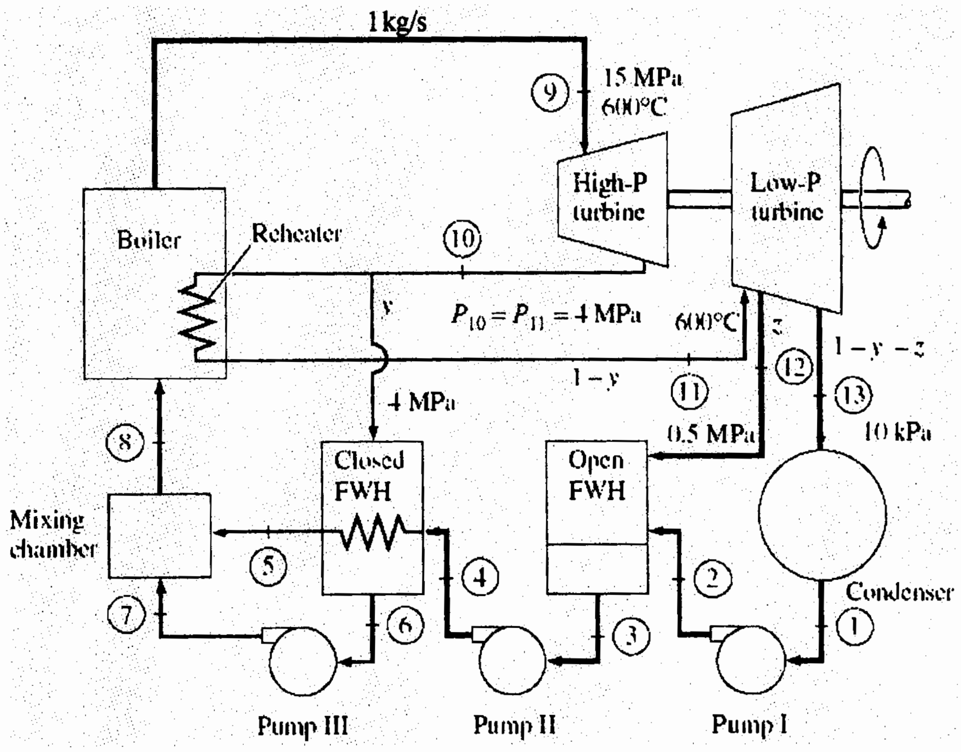
5. Consider a steam power plant that operates on an ideal reheat-regenerative Rankine cycle with one open feedwater heater, one closed feedwater heater and one reheater. Steam enters the turbine at 15 MPa and 600 °C at the mass flow rate 1 kg/s and is condensed in the condenser at a pressure of 10 kPa. Some steam is extracted from the turbine at 4 MPa for the closed feedwater heater, and the remaining steam is reheated at the same pressure to 600 °C. The extracted steam is completely condensed in the heater and is pumped to 15 MPa before it mixes with the feedwater at the same pressure. Steam for the open feedwater heater is extracted from the low-pressure turbine at a pressure of 0.5 MPa. Determine (a) the enthalpy of all 13 states in the cycle and the fractions (y and z) of steam extracted from the turbine, (b) the power required by pump I, II and III, (c) the total heat input to the cycle included the heat transfer at the reheater and (d) the thermal efficiency of the cycle. Also sketch the T-s diagram. (30 marks)



Hint: For simplicity of your analysis, you should make the assumptions that

1. The cycle is operated at steady state.
2. Kinetic and potential energy changes are negligible.
3. In both open and closed feedwater heaters, feedwater is heated to the saturation temperature at the feedwater pressure.
4. All pumps and turbines are isentropic.
5. There are no pressure drops (pressure is constant) in the boiler, reheater, condenser and feedwater heaters.
6. Steam leaves the condenser and the feedwater heaters as saturated liquid.