ASSIGNMENT # 4

Due in class 10/10/13 at 11.05am

Homework policy: Assignments will NOT be accepted past the due date. Lowest homework grade will be dropped.

Note: All reading and some problems below are from Moran and Shapiro, Fundamentals of Engineering Thermodynamics.

Suggested reading: Chapter 8: Vapor power cycles (sections on Regeneration)

PROBLEMS

[1] (25%) A power plant operates on a regenerative vapor power cycle with one open feedwater heater. Steam enters the first turbine stage at 12 MPa, 520 °C and expands to 1 MPa, where some of the steam is extracted and diverted to the open feedwater heater operating at 1 MPa. The remaining steam expands through the second turbine stage to the condenser pressure of 6 kPa. Saturated liquid exits the open feedwater heater at 1 MPa. For isentropic processes in the turbines and pumps, determine for the cycle (a) the thermal efficiency and (b) mass flow rate into the first turbine stage, in kg/h, for a net power output of 330MW.

[2] (25%) Consider a regenerative vapor power cycle with two feedwater heaters, a closed one and an open one. Steam enters the first turbine stage at 80 bar, 480 °C, and expands to 20 bar. Some steam is extracted at 20 bar and fed to the closed feedwater heater. The remainder expands through the second stage turbine to 3 bar, where an additional amount is extracted and fed into the open feedwater heater, which operates at 3 bar. The steam expanding through the third stage turbine exits at the condenser pressure of 0.08 bar. Feedwater leaves the closed feedwater heater at 205°C, 80 bar, and condensate exiting as saturated liquid at 20 bar is trapped into the open feedwater heater. The net power output of the cycle is 100 MW. If the turbine stages and pumps are isentropic, determine

(a) the thermal efficiency
(b) the mass flow rate of steam entering the first turbine, in kg/h

[3] (25%) Consider a regenerative cycle similar to the one in problem (2) but with only two turbine stages and one open feedwater heater. Determine the optimum extraction point and degree of regeneration. The conditions at the steam generator and condenser are the same as in
problem (2). Contrary to what shown in class, do not approximate the function \( I \) with a constant. The function \( I \) was defined in class and can also be found in the ME251 course web page.

[4] (25%) A regenerative vapor power cycle has three turbine stages with steam entering the first stage at 2500 lbf/in\(^2\), 1000°F. The cycle has two feedwater heaters, a closed feedwater heater using extracted steam at 600 lbf/in\(^2\) and an open feedwater heater operating at 60 lbf/in\(^2\). Saturated liquid condensate drains from the closed feedwater heater at 600 lbf/in\(^2\) and passes through a trap into the open heater. The feedwater leaves the closed heater at 2500 lbf/in\(^2\), 478°F. Saturated liquid leaves the open heater at 60 lbf/in\(^2\) and the condenser pressure is 1 lbf/in\(^2\). For isentropic operation of the turbines and pumps, determine the efficiency of this cycle.