HOMEWORKS 7 & 8

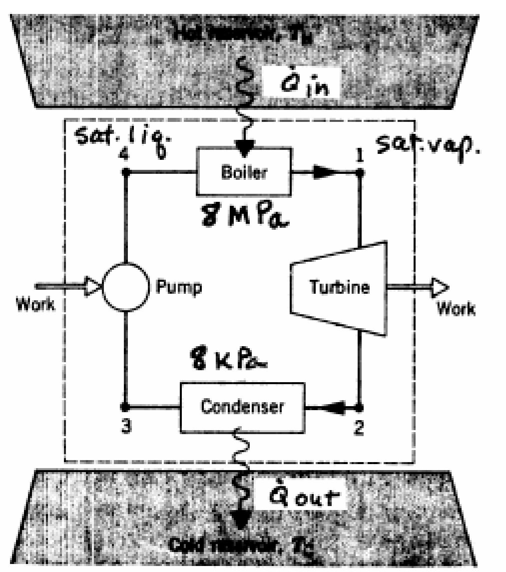
Handed out: Thursday, 11 October 2007
Due: Monday, 22 October 2007 by 5 pm

Notes:

1. Drop HW off in the designated homework box in Upson 123
2. Be sure that you **indicate your recitation section (and your name!)** on the top of the first page of your HW. **We will not accept late homework**.
3. Homework will be returned in your recitation. The TAs have been instructed to keep your HW **for only one extra week** in case you miss a recitation.
4. Problems with (*) refer to problems to be discussed in your recitation. We strongly advice you to try to solve these problems before you attend your recitation. Note that you should submit solutions to ALL problems in this HW including those indicated with a (*).

Problem 1 (Rankine Cycle): Water is the working fluid in a Carnot vapor power cycle. Saturated liquid enters the boiler at a pressure of 8 MPa, and saturated vapor enters the turbine. The condenser pressure is 8 kPa.

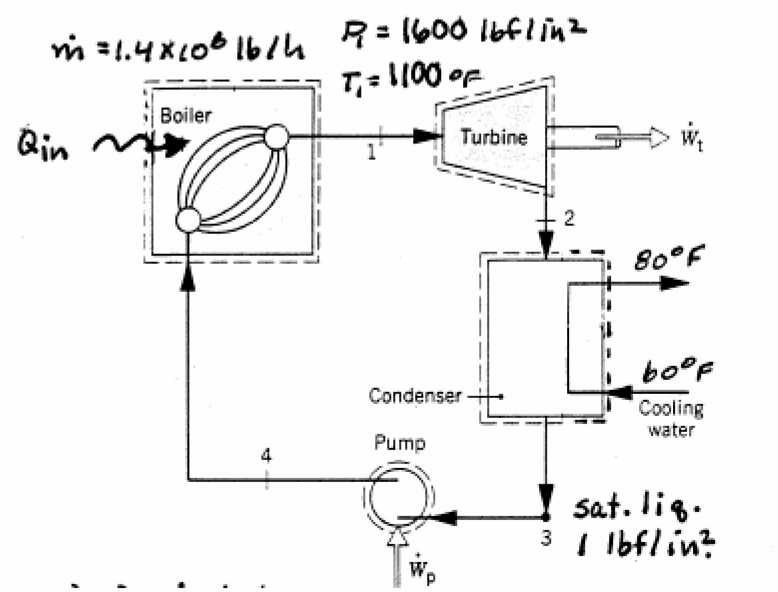
(a) Draw the T-s diagram
(b) Determine the thermal efficiency.
(c) Determine the back work ratio.
(d) Determine the heat transfer to the working fluid per unit mass passing through the boiler, in kJ/kg.
(e) Determine the heat transfer from the working fluid per unit mass passing through the condenser, in kJ/kg.



Note: The back work ratio is defined as: $bwr = \frac{(\dot{W}_p/\dot{m})}{(\dot{W}_t/\dot{m})}$

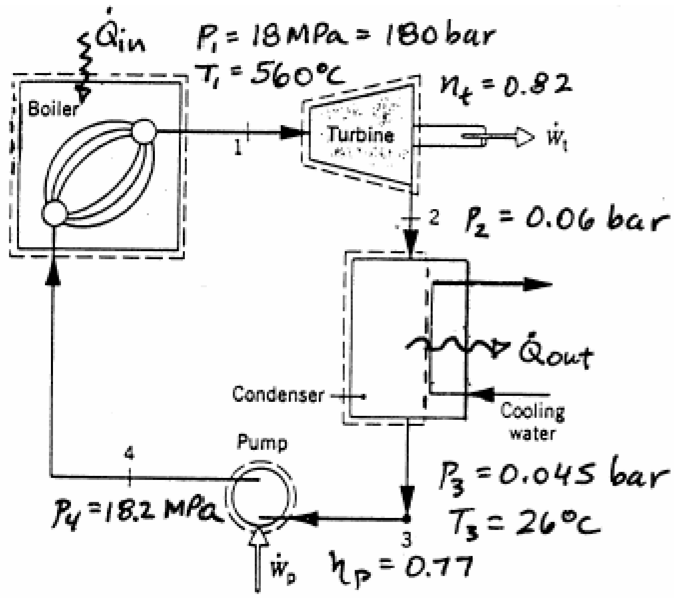
Problem 2 (Rankine Cycle): Water is the working fluid in an ideal Rankine cycle. The pressure and temperature at the turbine inlet are 1600 lbf/in.^{2} and 1100°F, respectively, and the condenser pressure is 1 lbf/in.^{2} The mass flow rate of steam entering the turbine is 1.4×10^6 lb/h. The cooling water experiences a temperature increase from 60 to 80°F, with negligible pressure drop, as it passes through the condenser.

(a) Draw the T-s diagram for the cycle
(b) Determine for the cycle the net power developed, in Btu/h.
(c) Determine for the cycle the thermal efficiency.
(d) Determine for the cycle the mass flow rate of cooling water, in lb/h.



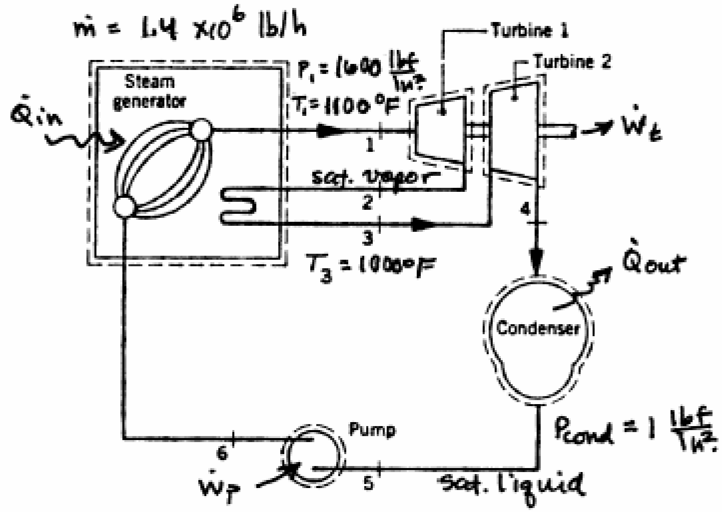
Problem 3 (*)(Rankine Cycle): Superheated steam at 18 MPa, 560°C, enters the turbine of a vapor power plant. The pressure at the exit of the turbine is 0.06 bar, and liquid leaves the condenser at 0.045 bar, 26°C. The pressure is increased to 18.2 MPa across the pump. The turbine and pump have isentropic efficiencies of 82 and 77%, respectively.

(a) Draw the T-s diagram
(b) Determine for the cycle the net work per unit mass of steam flow, in kJ/kg.
(c) Determine for the cycle the heat transfer to steam passing through the boiler, in kJ per kg of steam flowing.
(d) Determine for the cycle the thermal efficiency.
(e) Determine for the cycle the heat transfer to cooling water passing through the condenser, in kJ per kg of steam condensed.



Problem 4 (Reheat): The ideal Rankine cycle of Problem 2 is modified to include reheat. In the modified cycle, steam expands through the first-stage turbine to saturated vapor and then is reheated to 1000°F. The mass flow rate of steam in the modified cycle is the same as in Problem 2.

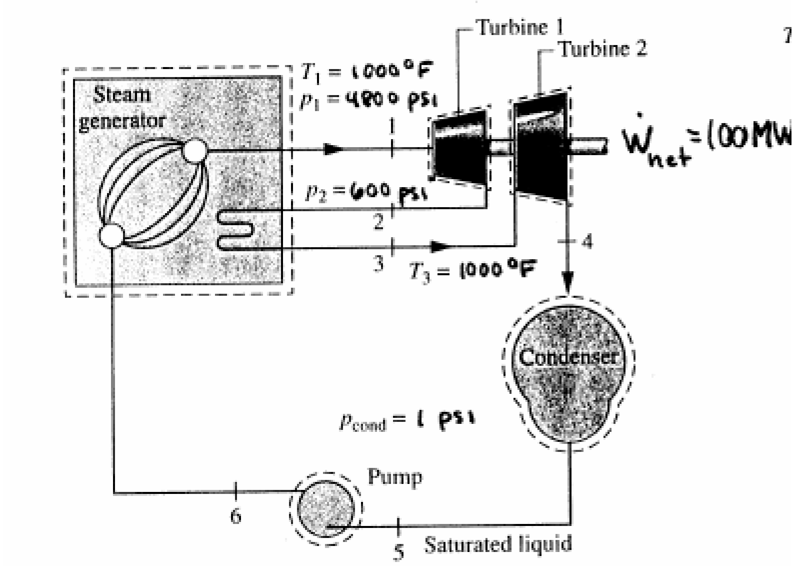
(a) Draw the T-s diagram
(b) Determine for the modified cycle the net power developed, in Btu/h.
(c) Determine for the modified cycle the rate of heat transfer to the working fluid in the reheat process, in Btu/h.
(d) Determine for the modified cycle the thermal efficiency.



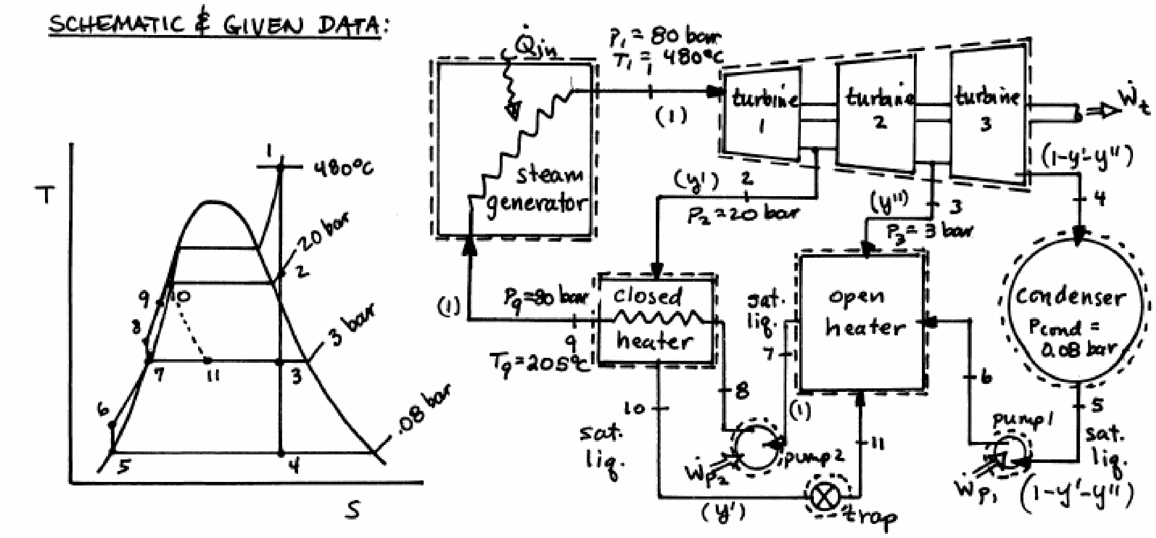
Problem 5 (Supercritical): Steam at 4800 lbf/in.^{2}, 1000°F enters the first stage of a supercritical reheat cycle including two turbine stages. The steam exiting the first-stage turbine at 600 lbf/in.^{2} is reheated at constant pressure to 1000°F. Each turbine stage and the pump has an isentropic efficiency of 85%. The condenser pressure is 1 lbf/in.^{2} The net power output of the cycle is 100 MW.

(a) Draw the T-s diagram

(b) Determine the rate of heat transfer to the working fluid passing through the steam generator, in MW.
(c) Determine the rate of heat transfer from the working fluid passing through the condenser, in MW.
(d) Determine the cycle thermal efficiency.

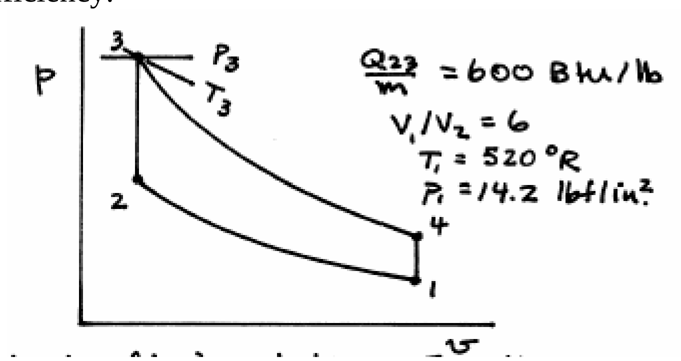


Problem 6 (*) (Regenerative): Consider a regenerative vapor power cycle with two feedwater heaters, a closed one and an open one. Steam enters the first turbine stage at 8 MPa, 480°C, and expands to 2 MPa. Some steam is extracted at 2 MPa and fed to the closed feedwater heater. The remainder expands through the second-stage turbine to 0.3 MPa, where an additional amount is extracted and fed into the open feedwater heater, which operates at 0.3 MPa. The steam expanding through the third-stage turbine exits at the condenser pressure of 8 kPa. Feedwater leaves the closed heater at 205°C, 8 MPa, and condensate exiting as saturated liquid at 2 MPa is trapped into the open heater. Saturated liquid at 0.3 MPa leaves 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.



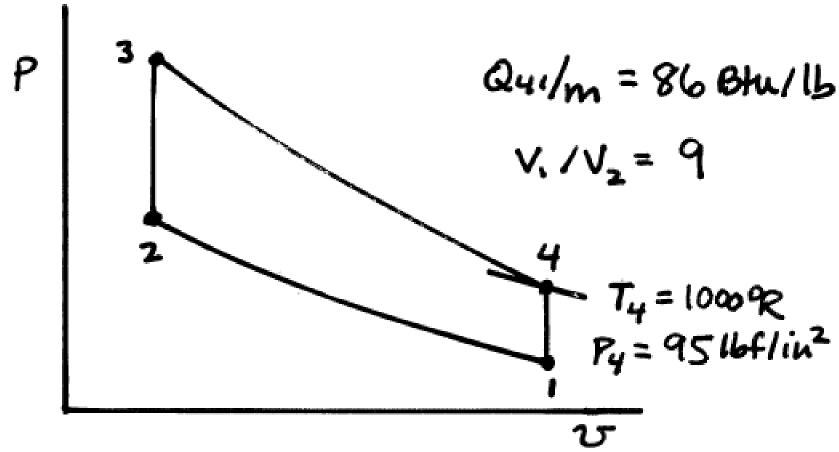
Problem 7 (Otto Cycle): An air-standard Otto cycle has a compression ratio of 6 and the temperature and pressure at the beginning of the compression process are 520°R and 14.2 lbf/in.^{2}, respectively. The heat addition per unit mass of air is 600 Btu/lb. Determine

(a) the maximum temperature, in °R.
(b) the maximum pressure, in lfb/in.^{2}
(c) the thermal efficiency.



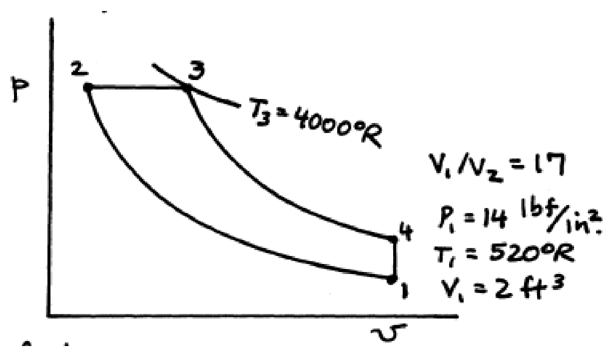
Problem 8 (Otto Cycle): The compression ratio of a cold air-standard Otto cycle is 9. At the end of the expansion process, the pressure is 95 lbf/in.^{2} and the temperature is 1000°R. The heat rejection from the cycle is 86 Btu per lb of air. Assuming $k = 1.4$, determine:

(f) the net work, in Btu per lb of air.
(g) the thermal efficiency.
(h) the mean effective pressure, in lbf/in.^{2}

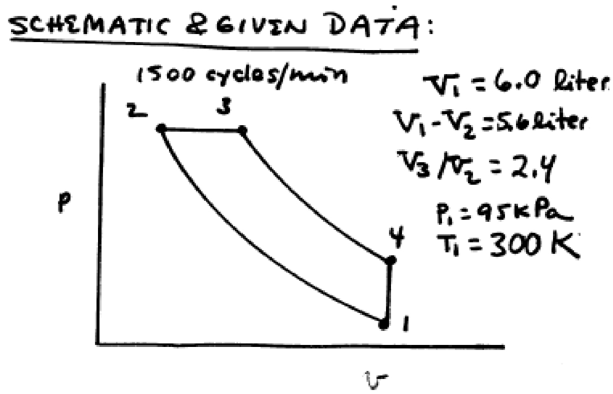


Problem 9 (Diesel Cycle): The compression ratio of an air-standard Diesel cycle is 17 and the conditions at the beginning of compression are p_1 = 14.0 lbf/in.^{2}, V_1 = 2 ft^3, and T_1 = 520°R. The maximum temperature in the cycle is 4000°R. Calculate:

(a) the net work for the cycle, in Btu.
(b) the thermal efficiency.
(c) the mean effective pressure, in lbf/in.^{2}
(d) the cutoff ratio.



Problem 10 (Diesel Cycle): The displacement volume of an internal combustion engine is 5.6 liters. The processes within each cylinder of the engine are modeled as an air-standard Diesel cycle with a cut-off ratio of 2.4. The state of the air at the beginning of the compression is fixed by p_1 = 95 kPa, T_1 = 27°C, and V_1 = 6.0 liters. Determine the net work per cycle, in kJ, the power developed by the engine, in kW, and the thermal efficiency, if the cycle is executed 1500 times per min.



Problem 11 (Dual Cycle): An air-standard dual cycle has a compression ratio of 16 and a cutoff ratio of 1.15. At the beginning of compression, p_1 = 95 kPa and T_1 = 300 K. The pressure increases by a factor of 2.2 during the constant volume heat addition process. If the mass of air is 0.04 kg, determine:

(a) the heat addition at constant volume and at constant pressure, each in kJ.
(b) the net work of the cycle, in kJ.
(c) the heat rejection, in kJ.
(d) the thermal efficiency.