MCG 2135 - THERMODYNAMICS I

Final Exam | Duration: 3 hours
7 December 2005 |
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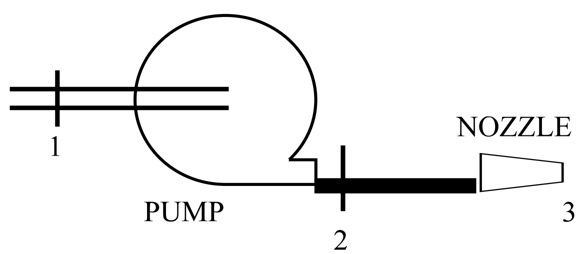
Closed book.. All calculators allowed. Tables for water properties are provided. Data and expressions are listed at the end of this exam paper.

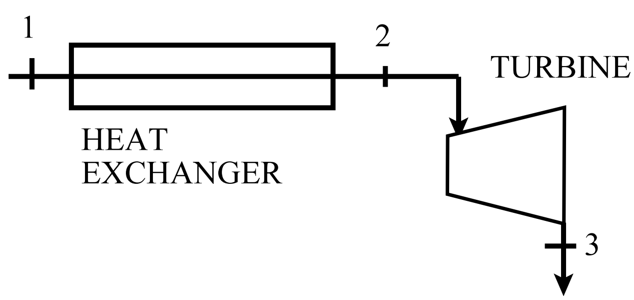
1)(7 marks) The schematic shows a pump receiving liquid water at $T_1 = 15°C$ and $P_1 = 100$ kPa. The pressure at the exit of the pump is $P_2 = 465$ kPa. Water is then admitted in a nozzle having a diameter $D_3 = 1$ cm. The pressure is $P_3 = 100$ kPa and the temperature $T_3 = 15°C$ at the exit of the nozzle. Assuming that kinetic energy is negligible except at the exit of the nozzle and that the process in the pump is reversible, calculate:

a) the work required by the pump in kJ/kg,
b) the velocity at the nozzles exit V_3,
c) and the mass flow rate.



2)(9 marks) The schematic shows part of a system used in cooling the cabin of an airplane. Air at P_1 = 200 kPa and T_1 = 107 °C enters a heat exchangeur where it is cooled at constant pressure until T_2 = 47 °C. Then air expands through an adiabatic and reversible turbine until P_3= 95 kPa where it is then admitted in the cabin. The mass flow rate is 1.5 kg/s.

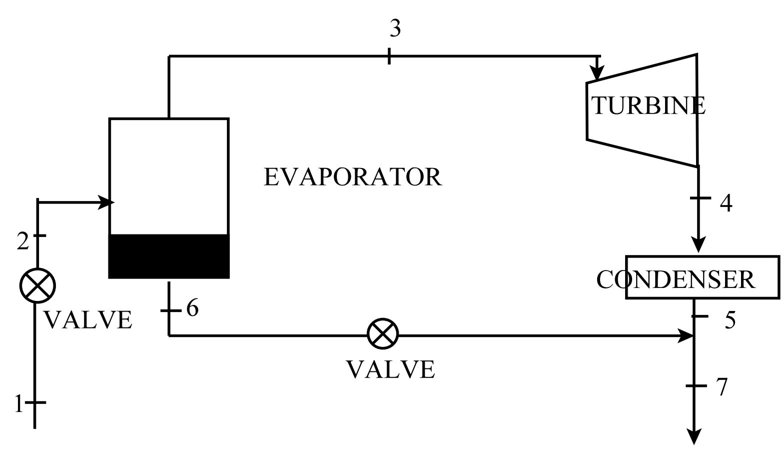
a) Calculate the power provided by the turbine.
b) Calculate the heat released by the heat exchanger.
c) Assuming that the turbine is irreversible and that its isentropic efficiency is 75%, calculate the temperature T_3.



3) (17 marks) The sketch shows a simplified schematic of a geothermal power plant producing energy using underground hot water having a mass flow rate of m_1 = 230 kg/s. Vapor is obtained by throttling the flow through a valve before entering an evaporator. Then vapor expands in a turbine and flows through a condenser. Liquid exiting the evaporator is throttled and is then mixed with the flow coming from the condenser. The following data are given:

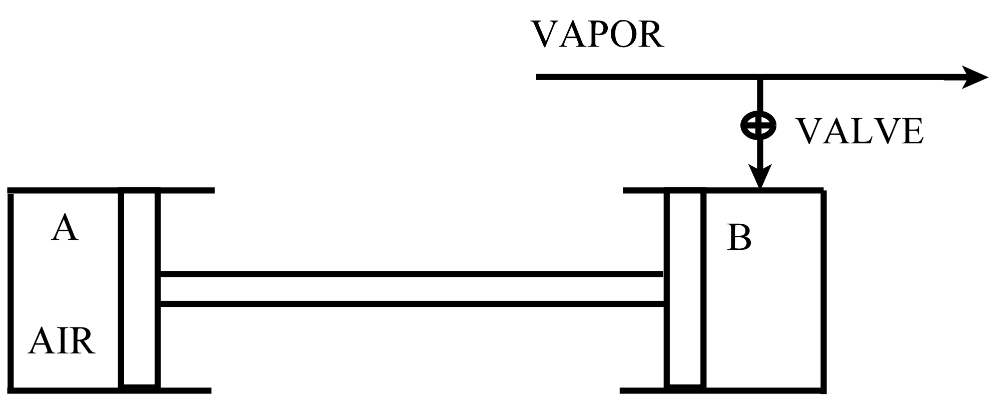
1. T_1=230°C, saturated liquid
2. P_2=500 kPa
4. P_4= 10 kPa, x_4 =0.9
5. Saturated liquid

a) Calculate the mass flow rate m_3 through the turbine.
b) Calculate the power provided by the turbine.
c) Calculate the isentropic efficiency of the turbine.
d)Calculate the temperature T_7.



4) (11 marks) The sketch shows an air compressor operating with water vapor. Initially, cylinder A contains air at 100 kPa and 25°C while cylinder B for water vapor has an initial volume equal to zero. Then the valve is opened and saturated vapor (dry) at 0.5 MPa is admitted in cylinder B until the whole system is in equilibrium. The vapor and air cylinders are both thermally insulated and the processes in A and B are reversible.

a) Calculate the work in cylinder B in kJ/kg (per unit mass of water).
b) Calculate the work in cylinder A in kJ/kg (per unit mass of air).
c) Calculate the ratio of masses in A and B (m_A / m_B).



5) (6 marks) Air at $T_1 = 35$ °C and $P_1 = 400$ kPa enters a compressor operating in steady state and exits with $P_2 = 1800$ kPa. The mass flow rate is 2 kg/s. The temperature of the surroundings is 20 °C. Assuming that the process in the compressor is isothermal and reversible calculate

a) the heat released,
b) and the total net change of entropy. Is the process possible?

Expressions and data for air

$W = (P_2V_2 - P_1V_1)/(1-k)$
$s_2-s_1=Cp_0 \ln (T_2/T_1) - R \ln (P_2/P_1)$
$T_2/T_1 = (P_2/P_1)^{(k-1)/k} = (v1/v2)^{k-1}$
Cp_0 air = 1.0035 kJ/kg.K
Cv_0 air = 0.716 kJ/kg.K
R air = 0.287 kJ/kg K
k air =1.4

Total marks for these exercises: 50