Massachusetts Institute of Technology
DEPARTMENT OF MECHANICAL ENGINEERING
Center for Ocean Engineering

2.611 SHIP POWER and PROPULSION

Problem Set #4 Basic Thermodynamic Cycles, Due: November 2, 2006

1. First Law refresher-

    a) Write the generic first law thermodynamic equation for a single inlet and single exit flow.

    b) What does this equation not take into account?

    c) Discuss the adiabatic process, the polytropic process and what it means for a process to be reversible.

2. Air at 10º C and 80kPa enters the diffuser of a jet engine steadily with a velocity of 200 m/s. The inlet area of the diffuser is 0.5 m^2. The air leaves the diffuser with a velocity that is very small compared with the inlet velocity. (Assume the diffuser is the system, flow is steady and air is an ideal gas (R=.287 (kPA*m^3)/(kg*K), enthalpy @ 283 Kelvin ~ 283 kJ/kg)

Determine:

a) The mass flow rate of the air
b) The temperature of the air leaving the diffuser.

3. Consider the tank system below. Tank A has a volume of 100ft^3 and initially contains R134a at a pressure of 100 kPa and a temperature of 313 Kelvin. The compressor evacuates tank A and charges tank B. Tank B is initially evacuated and is of such volume that the final pressure of the R134a in tank B is 800 kPa. Temperature remains constant. Determine the work done by the compressor.

4. Steam enters an adiabatic turbine at 8 MPa and 500C with a mass flow rate of 3kg/s and leaves at 30 kPa. The isentropic efficiency of the turbine is .9. Neglecting kinetic energy, determine:

a) Temperature at the turbine exit
b) Power output

5. A marine steam plant operates as a simple Rankine cycle with a turbine inlet temperature and pressure of 600 °C and 4 MPa. The condenser operates at a pressure of 20kPa. Assume that the turbine isentropic efficiency is 80% and the pump isentropic efficiency is 90%.

a. Sketch the cycle on T-s and h-s diagrams.
b. Determine the steam quality at exit from the turbine.
c. Determine the specific enthalpy change across each component.
d. Determine the net power of the cycle with a mass flow rate of 3 kg/s.
e. Determine the thermal efficiency of the Rankine cycle.