ME 444 / 544
Fall 2012

HOMEWORK SET # 1

Due: Tuesday 9 October
Review of 1st and 2nd Law of thermodynamics

#1. Steam enters an adiabatic turbine at 10 MPa and 400 °C at a rate of 20 kg/s and exits the turbine at 10 kPa with a quality of 92%. Find the power output of the turbine in MW and show the process on T-v and P-v diagrams.

#2. In a large steam-turbine power plant, steam with a quality of 90% and 0.08 bar enters a condenser with a mass flow rate of 130 kg/s. Cooling water from a nearby lake enters the condenser at 20 °C and exits at a temperature of 35 °C and will be used in a manufacturing facility and cooled again before it is returned to the lake. If the steam is to be condensed to saturated liquid and assuming that there is negligible pressure loss, what cooling water mass flow rate is required?

#3. Air enters a compressor of a gas turbine plant at ambient conditions of 100 kPa and 25 °C with negligible velocity and exits at 1 MPa and 347 °C with a velocity of 85 m/s. The compressor is cooled at a rate of 1500 kJ/min and the power input to the compressor is 250 kW. Determine the mass flow rate of the air through the compressor. Show the process on T-v and P-v diagrams.

#4. A de-superheater works by injecting liquid water (1) into a flow of superheated steam. With 2 kg/s of steam at 300 kPa and 200 °C flowing into the system (2), what mass flow rate of liquid water at 20 °C should be added to generate saturated vapor (3) at 300 kPa? What is the rate of entropy generation in kW/K for the process?

#5. Air enters an adiabatic nozzle steadily with at 300 kPa, 485 K and velocity 40 m/s and exits at 100 kPa and velocity 180 m/s. The inlet area of the nozzle is 80 cm^2. Determine

a) the mass flow rate through the nozzle
b) the exit temperature of the air in degrees C
c) the exit area of the nozzle in cm^2

#6. A simple Rankine cycle operates between pressure limits of 10 kPa and 6 MPa. Steam exits the turbine as saturated vapor with a mass flow rate of 11.2 kg/s. The net work output of the cycle is 16.4 MW. Find the thermal efficiency of this cycle.

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#7. An experimentalist claims that, based on measurement, a heat engine receives 320 kJ of heat from a source at 500 K, converts 180 kJ of it to work and rejects the rest as waste heat to a sink at 300 K. Are these measurements reasonable? Why?

#8. Steam enters an adiabatic turbine at 5 MPa and 450 °C and leaves at a pressure of 1.4 MPa. Determine the maximum possible work output per unit mass of steam. Assume changes in kinetic and potential energies are negligible. Draw a T-*s* diagram for the process.

☺ **#9.** Air is compressed by an adiabatic compressor from 1 bar and 12 °C to a pressure of 8 bar at a steady rate of 0.2 kg/s. Assuming constant specific heat, determine a) the exit temperature of the air and b) the *minimum* power input to the compressor, in kW. Show the process on a T-*s* diagram.

#10. A de-superheater works by injecting liquid water (1) into a flow of superheated steam. With 2 kg/s of steam at 300 kPa and 200 °C flowing into the system (2), what mass flow rate of liquid water at 20 °C should be added to generate saturated vapor (3) at 300 kPa at the outlet? What is the rate of entropy generation in kW/K?