GEORGIA INSTITUTE OF TECHNOLOGY

The George W. Woodruff
School of Mechanical Engineering

Ph.D. Qualifiers Exam – Spring Fall 2010

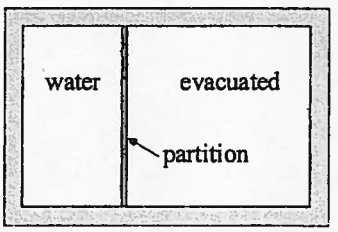
THERMODYNAMICS

EXAM AREA

Assigned Number (DO NOT SIGN YOUR NAME)

* Please sign your **name** on the back of this page —

Problem #1



A closed, rigid, insulated container is divided into two parts by a thin partition. The left side contains 1 kg of water as a saturated liquid-vapor mixture at 7 bar. The right side of the container is evacuated and has a volume of 0.2 m^3. The partition is removed and the water expands to fill the entire container. The final equilibrium pressure of the water is 3 bar. Find the initial volume and quality of the mixture and the final temperature of the water.

Problem # 2

A frictionless piston/cylinder is loaded with a linear spring, as shown schematically in the following figure. Initially, the volume of the cylinder is 20 L and it contains air at 200 kPa. A valve connects to a high-pressure air line at 800 kPa and 300 K. The ambient temperature is also 300 K. The cross-sectional area of the piston is 0.1 m^2, and the spring constant is 100 kN/m. The maximum volume of the cylinder is limited to 100 L by its stops. Once the valve is opened, air gradually flows in until the pressure inside the cylinder reaches 800 kPa. Assume that the air inside the cylinder is maintained at 300 K, throughout the filling process, by transferring heat to the surroundings.

a) Calculate the amount of heat transfer from the cylinder to the ambient during the process.

b) Calculate the total entropy generation due to irreversibility in the combined filling and heat transfer processes.

[Note that 1 L = 0.001 m^3. For air, use $R = 0.287$ kJ/kg·K .]

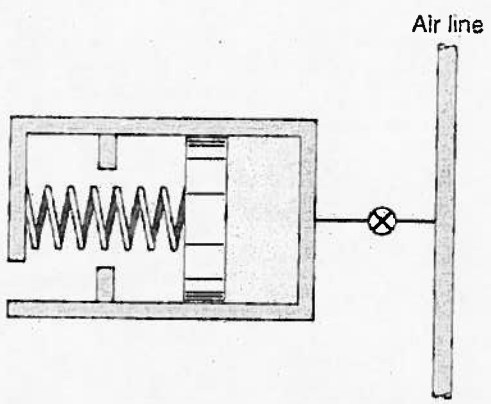


Figure 2. Schematic diagram (not to scale).

Problem # 3

Consider a gas power cycle consisting of an isothermal compressor and an isothermal turbine linked by an adiabatic regenerative heat exchanger, as shown schematically in Figure 1. The working fluid is a gas blend with molecular weight of 58 kmol, critical temperature of 50K and critical pressure of 200 bar. Property data are known at the inlets to the compressor and turbine (see Fig. 1), and the flow rate of the working fluid is 5 kg/s. Assuming that all components of the cycle are internally reversible, determine the following:

1. Draw the cycle diagram in P-v and T-s coordinates?
2. Turbine and compressor power output/input, respectively, and back-work ratio?
3. Heat input and thermal efficiency of the cycle (and compare it to the Carnot efficiency)?

Note: make sure to state and justify the assumptions you make to analyze the problem.

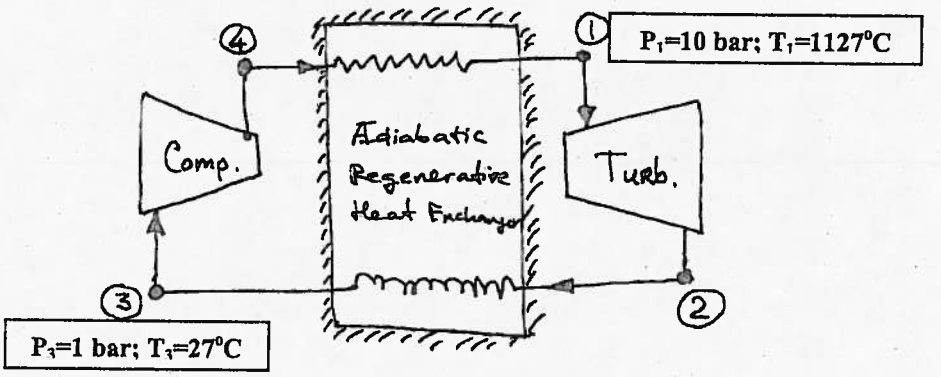


Figure 1. Schematic diagram of the gas power cycle and locations with known properties.