Tutorial 6

[4-32] A well-insulated rigid tank contains 2 kg of a saturated liquid-vapor mixture of water at 150 kPa. Initially, three-quarters of the mass is in the liquid phase. An electric resistor placed in the tank is connected to a 110-V source and a current of 8 A flows through the resistor when the switch is turned on. Determine how long it will take to vaporize all the liquid in the tank. Also, show the process on a T-v diagram with respect to saturation lines.

[5-29] Air at 80 kPa and 127°C enters an adiabatic diffuser steadily at a rate of 6000 kg/h and leaves at 100 kPa. The velocity of the air stream is decreased from 230 to 30 m/s as it passes through the diffuser. Find (a) the exit temperature of the air and (b) the exit area of the diffuser.

[5-51] Steam enters an adiabatic turbine at 10 MPa and 500°C and leaves at 10 kPa with a quality of 90 percent. Neglecting the changes in kinetic and potential energies, determine the mass flow rate required for a power output of 5 MW. [Answer: 4.852 kg/s]

[5-53] An adiabatic air compressor compresses 10 L/s of air at 120 kPa and 20°C to 1000 kPa and 300°C. Determine (a) the work required by the compressor, in kJ/kg, and (b) the power required to drive the air compressor, in kW.
Additional Homework Problems (Tutorial 6)

[4-23] A piston-cylinder device initially contains 0.25 kg of nitrogen gas at 130 kPa and 180°C. The nitrogen is now expanded isothermally to a pressure of 80 kPa. Determine the boundary work done during this process.

[4-24] A piston-cylinder device contains 0.15 kg of air initially at 2 MPa and 350°C. The air is first expanded isothermally to 500 kPa, then compressed polytropically with a polytrophic exponent of 1.2 to the initial pressure, and finally compressed at the constant pressure to the initial state. Determine the boundary work for each process and the net work of the cycle.

[5-30] Air enters an adiabatic nozzle steadily at 300 kPa, 200°C, and 45 m/s and leaves at 100 kPa and 180 m/s. The inlet area of the nozzle is 110 cm². Determine (a) the mass flow rate through the nozzle, (b) the exit temperature of their, and (c) the exit area of the nozzle. [Answers: (a) 1.09 kg/s, (b) 185°C, (c) 79.9 cm²]

[5-57] An adiabatic gas turbine expands air at 1300 kPa and 500°C to 100 kPa and 127°C. Air enters the turbine through a 0.2-m² opening with an average velocity of 40 m/s, and exhausts through a 1-m² opening. Determine (a) the mass flow rate of air through the turbine and (b) the power produced by the turbine. [Answers: (a) 46.9 kg/s, (b) 18.3 MW]

[5-59] Steam enters a steady-flow turbine with a mass flow rate of 20 kg/s at 600°C, 5 MPa, and a negligible velocity. The steam expands in the turbine to a saturated vapor at 500 kPa where 10 percent of the steam is removed for some other use. The remainder of the steam continues to expand to the turbine exit where the pressure is 10 kPa and quality is 85 percent. If the turbine is adiabatic, determine the rate of work done by the steam during this process. [Answer: 27,790 kW]

[5-67] Saturated liquid-vapor mixture of water, called wet steam, in a steam line at 2000 kPa is throttled to 100 kPa and 120°C. What is the quality in the steam line? [Answer: 0.957]
A hot-water stream at 80°C enters a mixing chamber with a mass flow rate of 0.5 kg/s where it is mixed with a stream of cold water at 20°C. If it is desired that the mixture leave the chamber at 42°C, determine the mass flow rate of the cold-water stream. Assume all the streams are at a pressure of 250 kPa. [Answer: 0.865 kg/s]